Jacques R. De Sloover
Anne-Laure Jacquemart

NYMPH ISLAND
(GREAT BARRIER REEF, QLD, AUSTRALIA)
FLORA AND VEGETATION OF A LOW WOODED ISLAND

DEPOT READING ROOM

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Jacques R. De Sloover
Anne-Laure Jacquemart

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(Great Barrier Reef, QLD, Australia)
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Foreword

In bringing together all the known data about the higher plants of Nymph Island, we intended not only to make an up-to-date inventory of the flora and plant communities but also to lay the framework for management perspectives.

Following a survey of some coral cays off the northern shores of Papua New Guinea (De Sloover 1992), the need arose for comparison with other cays further south in particular along the Great Barrier Reef[1], Australia). Excellent opportunities of starting such studies around Lizard Island, Queensland (Qld), obviously existed. Our first contact with Nymph Island in 1990 revealed the complex structure of that cay so that Eagle Islet was our first attempt to draw up a detailed account in the field (De Sloover & Liégeois 1997). In fact, Eagle cay quickly proved a singular case since, in view of the presence of such an extensive rookery for so many sea birds, its plant communities and flora could not provide a comprehensive picture of the climax vegetation we were looking for. We then turned to Turtell V island which is fairly near and, in spite of the impact of its nesting birds, we were able to draw a detailed map of this low wooded island[2] (De Sloover & Dufrêne 1999), which allowed us to make a synthesis of the data we had been compiling on Nymph Island since the early nineties.

Nymph Island has always been a case study in the sense that it is still difficult to position it in one of the proposed classification of the GBR coral islands. It is placed either among the low wooded islands typical of the reef's inner shelf or is linked to that category but remains somewhat apart. This characteristic played a significant role in the challenge that confronted us.

Information about the flora is scattered in various accounts. Nothing has been produced either on the structure and composition of plant communities or on their relationships to geomorphological features which are the only ones to have been thoroughly investigated. These features, though the only ones that had been fully explored elsewhere, looked rather sketchy for Nymph and gave a distorted picture of the real structure of the island and its genesis.

Certain trends in the checklist (Part 2) are best summarized by basic statistics. The number of flowering plant families on Nymph Is[3] has now risen to 63, genera to 121 and species to 143. We comment these figures in Part 2. Note that they do not easily parallel the results in the literature: the most recent compilation (Fosberg & Stoddart 1991) takes into account all the plant species recorded on some 80 coral islands from lat. 17°S to 9°45S along the GBR, that is more than 380 species, including those (i.e. *Sansevieria hyacinthoides*, *Philodendron lacerum* and *Phoenix dactylifera*) introduced by man for decorative purposes on some cays such as Green and Heron Islands. At this point it must be said

[1] Further abbreviated GBR.

[2] A 'low wooded island' and/or 'island reef' are the terms used to designate a category of coral islands. They have been in use since 1928 when the geographical section of an expedition was sent out to the GBR. According to Steers (1937), island reefs are ordinary patches of reef without any true lagoon and stand isolated both from the outer reefs and the mainland.

[3] In accordance with "The Cambridge Encyclopedia', we use 'Is' as the abbreviation for 'Island', instead of 'Isl.' or 'I.'.

that assessment of the status of a few species – alien, native or introduced – remains uncertain.

Our account could seem disproportionately long given the tiny land surface in question. Note that we have not adopted the policy of the Queensland Botany Bulletin official surveys because our aims and methods are quite different and above all the large working scale we selected for our project could not have been applied correctly to the huge land surfaces to be surveyed in Queensland. We aimed therefore to make a detailed inventory of the vegetation in relation to the island's soil properties.

The field observations for the present work were made between 1990 and 1997, during seven visits to the GBR. The manuscript was finished by the end of 2006, but its publication was delayed until 2008.

The methods followed here are not outlined in a section at the beginning of the book, but inserted in the concerned parts, i.e. in 3.1 (study of plant communities) and in 4.2.1 (methods for mapping the vegetation units).

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We are also deeply indebted to the Queensland Department of Environment and Heritage (Queensland National Parks and Wildlife Service) for delivering permits allowing us to interfere with forest products for scientific purposes in the Nymph National Park. We cannot thank its staff enough for their unfailing contribution to our work. Our contacts with the Department of Lands, Woolloongabba, Qld, regarding aerial photographic services were exemplary because its personnel gave us access to the essential 'run' over Nymph Is. George Batianoff from the Queensland Herbarium, Brisbane, helped with determination problems, notably with *Casuarina* specimens.

We are also deeply grateful to Prof. Joseph Dufey for the soil analysis facilities and especially for improving the sections devoted to soil features, also to Etienne Gilot for ^{14}C datation of buried charcoal and to Damien Lanotte who was in charge of the level gauge in the field. As a token of a long-standing friendship, Marie Evrard offered to design the maps. All our thanks to Bridget O'Meara for the review and English improvement of the manuscript.

We thank Michel Baguette and Catherine De Sloover whose help in the field was much appreciated. With us they experienced the long, dry, hot weeks on a so-called dream coral island devoid of the most basic conveniences but lavishly provided with mosquitoes and green ants!

Abstract

Between 1990 and 1998, the flora and vegetation were investigated on Nymph Island, a low wooded island of the inner northern Great Barrier Reef, quite recent (less than 6000 years) in the reef's overall history. The island's geomorphology and soils are deciding factors that determine the vegetation types and fix their distribution. In the first part of our paper we argue that their diversity and genesis are essential characteristics which explain the habitats affected by peculiarities in plant formation and structure. These singularities have led to the use of many specific terms related to these structures and their genesis. They are only used here because they designate the plant communities.

Up to 1991, the known flora amounted to only fifty species successively collected or noted down by Steers (1937), Stoddart (1973) and Heatwole (1984). By the end of our study, the checklist came to 143 species of higher plants allocated to 63 families. Ninety-three of them are thus reported from Nymph Is. for the first time.

Data related to plant communities were compiled from 120 quadrats subjectively distributed to represent all the detected physiognomic vegetation types. Surveys were made according to the principles of the Zurich-Montpellier system as adapted by Bridgewater (1971). Ten vegetation tables are presented comprising 17 vegetation units. Among them the most noteworthy are: (1) two seagrass communities on the reef platform, (2) *Sarcocornia quinqueflora* samphires and *Sporobolus australasicus* saline meadows on the low platform, (3) five mangal communities (*Aegialitis annulata*, *Rhizophora stylosa*, *Osbornia, Bruguiera-Ceriops* and *Lumnitzera*) distributed according to the significance of wave action and/or the height and frequency of the tides, (4) *Pemphis acidula* ribbon scrub near the basis of shingle levees or on the high platform, (5) *Lepturus repens* tussock grassland on higher parts of shingle deposits, (6) the upper beach herbfield community with *Ipomoea pes-caprae*, (7) *Casuarina* woodland on lower terraces of the sandy cay and *Manilkara* low closed forest and associated shrubland on the higher sandy terrace. Special attention was paid to the apparent heterogeneity of *Casuarina* woodland on the gentle seaward slope of the cay from the high water mark to the *Manilkara* broadleaf forest: and lastly, *Casuarina* growth features associated with soil characteristics and vegetation structure form a unique woodland built up, thanks to the establishment of at least three successive sowings on as many consecutive terraces.

A vegetation map and four transects point to the spatial distribution of the vegetation units as well as to the relationships between these units and geomorphological structures.

Finally, a geomorphological reappraisal is inserted as a by-product of the research project. It gives the previously unknown geomorphological features that emerged from the detailed vegetation mapping. The main result shows that the ancient island contour clearly looks smaller than the present-day one. Thus, the higher platform that is still visible and demarcated by a cliff on the southern shore seems to vanish under the western shingle levees. Yet it continues further north and its cliff can still be seen on the southern edge of the so-called northern pool, which in fact is the site of an ancient moat. The supposed delineation of that high platform could represent the first contour of the island before sea recession from a higher stand. Other features such as pools, shoreline outlines and successive sand terraces are discussed too.

Part 1
Introduction

1.1. History and official status of the island

Nymph Island, a remote coral island of the inner barrier reef, is located off the north coast of Queensland southeast of Cape Melville (14°39'S/145°15'E), 22 km from the coast and 33 km from outer ribbon reef (McLean & Stoddart 1978). Its surface area reaches some 65 ha.

On old admiralty charts, the island was known as Enn Island (Steers 1928) when some unnamed coral cays were designated by a letter from the alphabet. However, as this was not an easy way of reporting on the islands in question, the Sailing Directions for Queensland (1939) decided to rename the islands: the initial letter of each island's name, phonetically speaking, was retained so that cay 'Aye' became 'Iris', 'Tih' became 'Trent', 'Enn' became 'Nymph', and so forth.

Nymph Island became part of the Queensland National Parks in 1980. Within the GBR Marine Park, it belonged to the Marine National Parks Zone A (MNPA). Under the zonal planning of the GBR Marine Parks (Cairns Section 1992), the coral island and its waters called for increased protection and came to be considered as a National Park Zone (NPZ). It was seen as a worthwhile complement to the Queensland National Park because of its well-developed reef platform with an unusual perched lagoon at low tide. Surrounded by important mackerel grounds and representing an anchorage site especially for yachts, it is a valuable conservation site, of importance to birds including the Torres Strait Pigeon (*Ducula spilorrhoa*) and large birds of prey, namely Ospreys and White-bellied Sea-Eagles.

E. F. Kemp was the first to map Nymph (still known as 'Enn'), under the direction of Steers (1938, p. 79). They made it from drawings in the field, measurements being taken by pacing and bearings with a prismatic compass. In spite of those simple means, the general structure and the main features of the island were reproduced (fig. 1A).

As far as we know, Maxwell (1968) was the first to publish an aerial photograph of Nymph. Even so, this small, somewhat blurred document shows the presence of more than one perched lagoon or moat and the intricate pattern they form with the dry land of the sand cay.

Flood (1984) published the next map from a modified, unpublished map drawn by Stoddart in the seventies. The physiographic zonation looks very sketchy. For one thing, it gives a largely inaccurate picture of the vegetation where mangroves surrounding a pool appear by the low woodland covering the sand cay (fig. 1B). That mistaken interpretation seems all the more incomprehensible since excellent aerial views were already available by 1982 and they are referenced in the booklet.

It was not until 1994 that Smith's document was produced: the small map lacks detail but gives correct information not only about the sequence of moats which explains the genesis of the island but also about the zonation of a few comprehensive vegetation units, for example herbland and sparse vs. dense woodland.

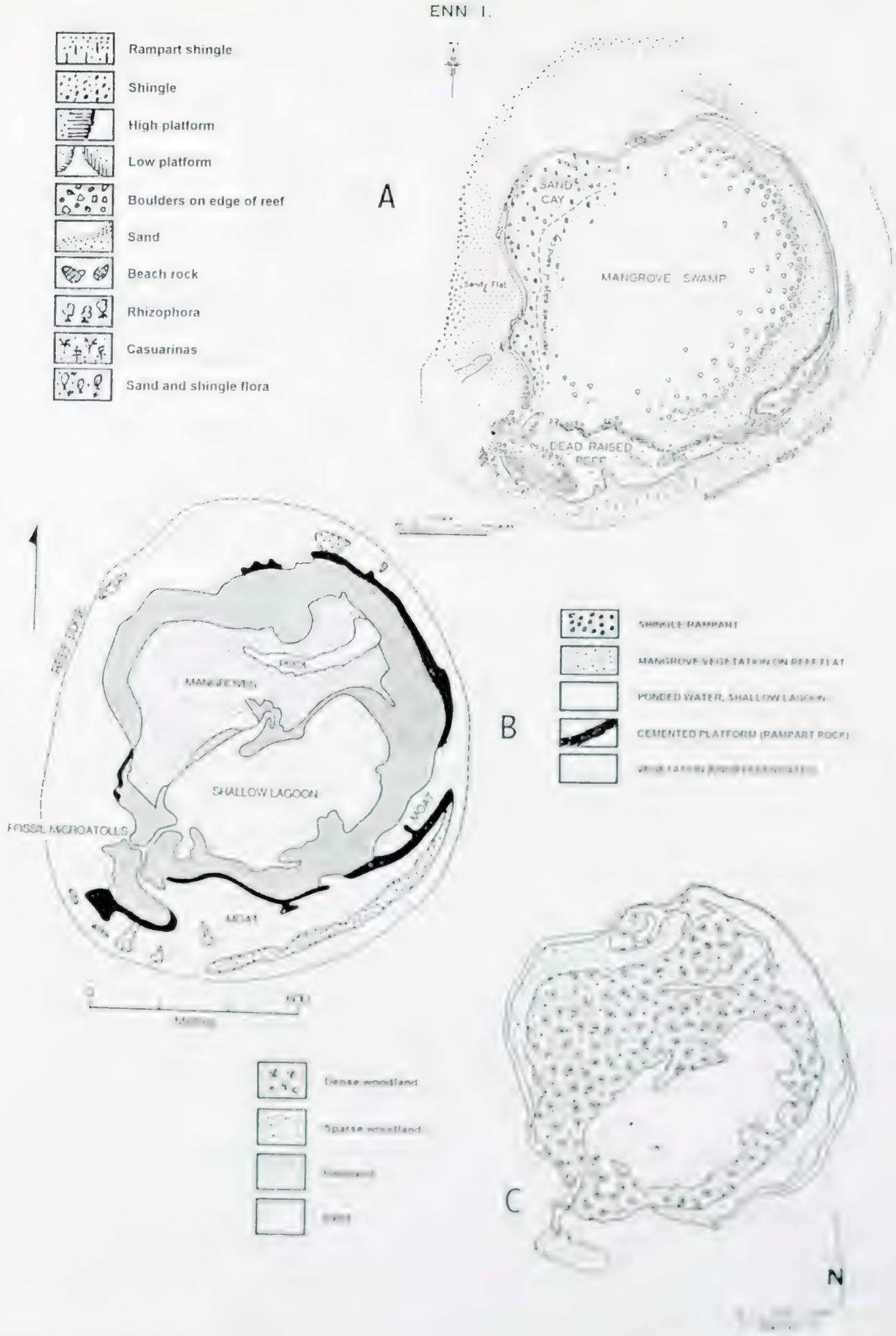

Figure 1 Three earlier maps of Nymph Is

A Morphological map of Enn Is (= Nymph Is) from Steers (1937)

B Morphological zonation of Nymph Is, modified from unpublished map by Stoddart, taken from Flood (1984)

C Topographic and vegetation map of Nymph Is, from Smith (1994)

1.2. Climate

Nymph Island has a tropical monsoon climate with high rainfall (200-300 mm/month) in summer, that is from December to April during which 90% of the annual rainfall is recorded. Rainfall is minimal between the months of June to November that correspond to the hot dry season. The mean annual rainfall averages 2000 mm on the continental Lizard Island that is situated some 25 km to the east but could be lower on a flat relief island like Nymph. Nevertheless, on Low Isles, a low wooded island located about 20 km to the South, annual precipitation reaches 2031 mm. Like the other reef islands, Nymph is in the cyclone belt and tropical thunderstorms can bring heavy rain.

Temperatures range between 27 to 32°C during the rainy season. These values fall by only 2 to 3°C during the dry season (minimum between 22 and 25°C).

1.3. Physiographic features

Round in contour and about 850 m in diameter, Nymph Island extends over some 65 ha and its elevation just exceeds three metres above datum. Barely separated from the south-eastern coast of Nymph Island, we find a tiny islet linked to it by a short tombolo.

1.3.1. Geological features

Nymph *Island* has always been a case study as it is difficult to insert into any of the classifications proposed for the GBR coral islands (Steers 1937). It is placed either among the so-called low wooded islands typical of the inner-shelf coral islands or linked to that category but somewhat apart. It lies on a high-perched reef forming a patch on that reef platform of which it occupies over 50%. Its relatively young core is supported by a much older coral platform dating from the Pleistocene Age: a pre-Holocene disconformity surface has actually been located at 9.35 m under the present sea level (Harvey 1977). According to Flood (1984), this shallower depth compared to that found under Three Isles might explain the advanced stage of morphological development of the Nymph reef. As a foundation, the old eroded reef is itself anchored to the lower Miocene continental shelf at an average depth of 50 m. The substructure of the modern reef is Miocene in age like much of the reef volume. Barrier reef development continued through Pliocene and its surface features are a consequence of Pleistocene and Holocene sea level fluctuations. The recent coral island of Nymph has thus been built in Holocene times, roughly 6000 years BP.

1.3.2. Consequences of alterations in sea level

The geological structures mentioned above and many younger ones are the result of eustatic changes, with levels varying over the past 120,000 years from -120 meters to over +10 meters compared with today's level.

Periods of regression during the Quaternary led to the planation and erosion of older reefs whereas prolific reef growth followed during transgressions (Veron 1978). In the course of the last major glaciation (15 to 20,000 years ago) when so much of the world's water was locked up as ice in the polar caps, the sea must have withdrawn from most of the northern region of the GBR so that the ancient barrier reefs would have formed high limestone ranges like walls separating the ocean from the Queensland shelf. That shelf was an emerged plain traversed by rivers and staked out with low mountains that now

form the continental islands, for instance Lizard Island, interspersed with steep-sided and flat-topped limestone hills like the base of Nymph Island.

After the last great glaciation, the sea rose slowly, reached the level of the old continental platform and overran the shelf again. Coral growth swept anew through the abandoned land and resettled there once more; sediments started to accumulate on the lee of the reefs and fill in the lagoon. The old eroded platforms would have reached down to a mean depth of 12 m below present sea level (in the range of -17 to -9 m): these worn-down old surfaces then became available as settling sites and coral would have grown steadily upwards to the surface; when the sea level reached its present mean level by about 6200 BP, growth slowed down at last or was confined to the edges of the reefs.

According to Steers (1937), Hopley (1982) and many others, the sea has stayed at about the same level since then or has risen at most by 1 m. On the other hand, Meischner (1996) considers that sea level has risen by about 3 m and has oscillated around that value, so that the present level was only reached a few hundreds years ago.

1.3.3. Geomorphological features

Coral island geomorphology has been deeply affected for most of the last century. Many significant features that are now largely accepted imply singular processes and terminology whose technical terms like 'rampart' or 'moat' stem from medieval castle defences.

We now review these features briefly keeping in mind our main purpose, which is to provide a detailed survey of vegetation units and their links to soil properties. That is why we rank them arbitrarily within six broad items related to the recognized vegetation units.

1.3.3.1. The best Nymph Island anchoring site is on the lee in the middle of the northwestern coast. Depending on the tide, landing could be right on the sand cay or at the edge of the reef behind the boulder zone (fig. 2), in which case one has to cross the entire **reef flat** to reach the shore after wading for some 100 m.

The outer reef flat shows an outer living coral zone, then comes the boulder zone and next a very gentle slope strewn with rubble or even shingles: on low spring tides, shallow pools of water only a few cm deep cover the sparse **sea grass beds**. Some areas are mostly sandy in the same way as the reef flat extending between the satellite islet and the cliff lining the main island south of the lagoon outlet and never completely dry up even at the lowest tides; these areas form a so-called moat (cf. 1.3.3.6).

1.3.3.2. Shingle ridges are a noteworthy feature of the windward eastern coast of Nymph and form the so-called **ramparts** (fig. 5). These shingle deposits extend from the southern to the extreme northeastern coast where they seem to die out. They are also progressively weaker northeastwards. Furthermore they take a right bend to the southwest where they build up the rampart, enclosing an older moat and associated mangroves, and mingle with the sand deposits of the cay. Hence, the term 'Composite Island' given in particular to Nymph seems to be derived from the complex nature of its sediments (fig. 3).

The starting point of the asymmetric ridges stands at the outer edge of the reef top where coral shingle are loosely heaped up by the waves and continually reworked, tending to move inwards (fig. 4). On the lee in its inward progression the outer rampart breaks up and its components are strewn on the reef flat (fig. 2) but on the wind they make headway and eventually merge before coming to rest against or over the upper platform. Shallow

ponds are trapped behind the outer ramparts after each ebb tide. Three to four successive ridges make up this impressive coastline. The younger ones are brilliant white in colour and remain like this while occasionally moved by waves on the 100 m reef flat. On the other hand inner ridges or levees beyond the reach of the waves acquire a dull appearance, the upper and innermost ones even becoming corroded and dark through incrustation with blue green algae (fig. 5).

Horizontal **conglomerate platforms** (the so-called promenades or rampart rocks) which are made of cemented [4] shingle components of older rampart systems have been formed in former moats. They thus appear at elevation between the ranges of modern intertidal cementation (MHWS) and were formed between 1500 and 500 years BP. Frequently overridden by shingle ridges moving landwards they end up covered with patches of, at times dense, **saline meadows** overrun at high tide (fig. 5).

1.3.3.3. An **upper platform** of rampart rock is prominent. Lithified remnants of an ancient reef flat form horizontal bedded platforms perhaps easier to recognize here than on other low wooded islands. Rising just over 2 m above the most recent low platform, its cliff may be notched at the base and even undercut to 1 m deep or more (fig. 6, 7, 8).

On Three Isles and other low wooded islands, upper platforms in the same way as high terraces could have been formed during a high sea level stand above present. On Nymph Is, that sea level stand may have exceeded 1 m, the maximum level identified by most geomorphologists. Radiocarbon dating of upper platforms on Nymph Is points to 3540 years BP whereas the cements are only 2350 years old (Scoffin & McLean 1978). These ages are about the same as on other low wooded islands with equivalent features.

The width of these high platforms varies from around 10 m to more than 50 m and karstic erosion on their outer edges severely bites into the platforms in the form of deep circular potholes. These destructive processes may isolate blocks from the continuous scarp when it lies near the inlet of the lagoon at the southern tip of the sand cay. This situation is consistent with a fall in sea level since the consolidation of the upper platform some 3000 years ago (McLean & al. 1978).

On Nymph Is, the oldest inner shingle ridges partly overtop the western upper platform to an elevation of around 3 m.

1.3.3.4. On account of its irregular outline, the leeward elongated **sand cay** of Nymph Is (fig. 1) could have been built by several smaller cays that finally came together. Its bulk, apparently sandy, is in fact formed of mixed coral sand, coral rubble and even large shingles so that digging for soil profile is often strenuous. Hopley (1982) suggested that the shingles originated during storm events, whereas sand was added during calmer weather. Radiocarbon dating of that largely sandy substrate is not available for Nymph. Datings were nevertheless obtained for other low wooded islands such as Bewick or Three Isles and all were comprised between 2900 and 3400 years BP. Nevertheless, the inland sediments from mixed sand-shingle cays like those studied from the Turtell Group were dated around 5000 years BP, values which would probably be much the same on Nymph. These results point to a period of high reef-top productivity some 5000 years ago and suggest

[4] According to Flood (1984), cement is thought to be derived from sea water and is made either of cryptocrystalline high Mg-calcite in rampart rock or of aragonite needles in beach rock.

that these sand cays are relatively stable deposits (McLean & Stoddart 1978). This observation implies that new detritic material was not added recently but has mostly been reworked either by wind-induced currents or by periodic storms locally redistributing that material. In fact on islands like Nymph, as a consequence of the reef top becoming more packed with emergent sedimentary deposit, the available space for the production of primary sediment has been reduced and reworking is the only way to fashion the island's shape.

Two distinct levels can sometimes be recognized which were termed high terrace and low terrace by McLean & Stoddart (1978). **High terraces** (more than 3 m above tidal datum) have generally deeper soils with an increasing depth of organic staining under dense broadleaf forest. **Low terraces** support only open scrub or *Casuarina* woodland on incipient soil development. Their ages are consequently as follows: high terraces could have been deposited around 5000 years ago, lower terraces, up to 2 m high, could date back to around 3000 years BP while the lowest ones could date from the last few hundreds years.

Fragments of **beach rock** are conspicuous along the cay shore and are awash at high tide. This 'rock' is formed within the tidal range by daily soaking and evaporation. It is composed of cemented material similar to that of the beach and its thickness may reach at least 30 cm. Once lithification has occurred, the cay seems more stable or inversely it could be said that once the cay has been stabilized by vegetation, the beach rock may appear.

1.3.3.5. When corals approached the surface during their upward growth, growth conditions in the central zone of the reef were progressively modified. Growth rate probably slowed down while on the edges of the reef coral growth continued, thanks to the better growing conditions. So gradually, an **inner lagoon** was formed, coral growth was maintained but finally stopped with increasing sedimentation. The question is unsolved as regards Nymph Island. However, according to Hopley (1982), a reef narrower than 1.75 km as on Nymph would not normally have lagoons.

Nevertheless, a **shallow lagoon** takes up the southwestern part of Nymph (fig. 9). It fills up at high tide and empties at low, through a restricted inlet (fig. 10) that reaches the reef platform along the tombolo linking the main island to the southwestern tiny islet. The current in that channel is often strong and depending on whether the tide is rising or ebbing, stream flow alternates. A relatively narrow belt of **mangroves** completely lines the central lagoon and a few tiny *Rhizophora* patches became firmly established right in its middle. We emphasize this feature because among the low wooded islands, it is specific to Nymph Island. In typical low wooded islands like Three Isles, a large stretch of a tall closed or open canopy mangrove is the windward matching piece of the sand cay lying at the opposite end of the reef top. This typical arrangement is conveyed through generalized zonation as in Flood's model (1986: 67, fig. 21). It is possible that owing to the relatively narrow round-topped reef, the still open, as yet unfilled lagoon remained in place, thus combining wind- and leeward features. Sheltered by this particular high upper platform and the overlying shingle ridges, the lagoon could remain protected against the unremitting supply of detritic material when the sea level dropped.

1.3.3.6. In the context of coral islands, the term '**moat**' refers to a seawater pond isolated from the ocean at least at low tide. On Nymph, 'living' moats are confined to the extreme

south and southeastern shores. Two moats of different conformation lie side by side: the first one (moat nr 1, fig. 4) lined with pure coral sand surrounds the whole extreme southern part of the island. This broad, shallow moat stretches and narrows eastward for over 400 m. Many living corals are found there, in particular micro-atolls. This moat looks like a sunken reef flat protected by shingle ridges. The second more striking moat (moat nr 2, fig. 8, 11 and 12) succeeds moat nr 1, right on the east and fits between the eroded rock face topped by the upper platform and the cemented lower platform.

As shown at least in part on Smith's map (1994), three more semi-permanent 'ponds' of decreasing size succeed one another anticlockwise from those mentioned above. Not all of them are small lagoons but at least one is a true **moat** (moat nr 3, fig.13 & 37). Whatever the nature of the moats, they are found in a decreasing age set.

1.3.4. The soils

On coral islands, soils as substratum for plant growth are mainly derived first from corals themselves and to a lesser extent from other reef organisms such as foraminiferan tests and calcareous alga skeletons. Volcanic ash and mainly drifting pumice are frequently incorporated into the soils on Nymph, sometimes in great amounts into the sand or in pure bed. In addition to that parent material, part of the organic material has a marine origin as well. Nevertheless, coral island soils progressively develop a singularity which demarcates them sharply from the sea because the vegetation they form clearly indicates insular ecosystems. However, as most coral islands like Nymph are relatively small, they are never completely isolated from the sea, given that mineral accession from sea water aerosols occurs continuously although in small quantities.

The structural and chemical properties of coral island soils are not often reported (Fosberg 1976). There are no phosphatic soils ('Jemo soils') or typical highly humic soils ('Arno atoll soils') on Nymph although soil profiles under central *Manilkara* forest reveal highly humic A horizons that could be put in that category. In general, soils from the Pacific cays are slightly altered coral sands known as 'Shioya soils' (Stone 1953, in Fosberg 1976). If unaltered or slightly altered, their pH is of about 8.3 but, when humus is incorporated, the pH may drop to 7.5 or 7.0. Those soils are deficient in almost all nutrients except calcium and, to some extent, magnesium.

1.4. Human factors

Aborigines continuously frequented the area, including among others, Laura Valley on the mainland, from probably more than 10,000 years BP i.e. long before the present vegetation started to invade Nymph Island. No permanent settling traces in the form of midden deposit have ever been found on the island. On the contrary, large middens are recorded from the nearby Lizard Island on the probable site where Cook and Banks noticed 'Indian' dwellings in 1770 (Beaton 1978).

As we noticed even in 1990, aborigines still go round Nymph Is. In that perspective, traces of long-standing or recurrent stays are borne out by local dark grey coloured surface deposits contrasting in colour with the pale coral sand found beneath them. Ashes and decomposed organic matter give a dark colour to the soil. In the same spot, four continental rock fragments, such as quartz-bearing quartzite and red decomposing sandstone fragments associated with *Melo* and *Tridacna* shell fragments were discovered on the lee side

near the summit of the Nymph Is cay. These deposits are evidence of the exploitation of food resources by coastal inhabitants (Beaton 1978). On the same cay, we unearthed in 1992 burnt left-overs, e.g. *Trochus* shells under the *Casuarina* woodland. When digging the sand in undisturbed soil profiles, a grey-brown 30 cm thick layer (Ah horizon) with black humus pockets and charcoal at the base was found under a grey-beige 5 cm thick sandy layer. Charcoal dated from 380 to roughly 60 BP (Lv 2041). Considering that the site is near the sandy shore, these remains could be signs of 'recently' cooked meals by visitors to the cay. It is quite certain that the central lagoon has always been a good place for fishing mud and sand crabs (Smith 1994).

An earlier settlement probably during the 19th century is confirmed by the presence of a coral boulder-lined well, still easily uncovered in the bushland; likewise, the foundations of a building were still visible ten years ago. Smith (1994) who recorded these remains was nevertheless unable to find documents written about the time of the settlement. The site was very likely the work place of sea cucumber fishers around 1880, at the time of the Watson residents on Lizard Island. Large broadleaved sawed stumps were found in the nearby low woodland that were partially and probably felled to boil water for the men's *bêche-de-mer*.

The impact of man on Nymph Island vegetation has thus remained quite limited. On this now protected land thanks to its National Park status, the worst that might happen are invasive plants insidiously introduced by brief visitations. Several of these potential invaders were found on Nymph (cf. Part 2) but until now, none of them have taken over the cay.

Part 2
The Flora

2.1. History of plant collection

According to Hill (1974: 725) "terrestrial flora (of coral islands) is a very restricted one, of only 30 to 40 species, practically all of which are of wide distribution in the Indo-West Pacific Province."

On the eighty cays of the northern GBR for which written reports or specimens are available, Fosberg & Stoddart's (1991) compilation listed 380 species in 86 families. From this checklist, they assessed that the flora of the GBR cays is mostly characterized by species linked to continental Australia and thus lacking on cays from other oceanic provinces. Thus the present score does not seem as meagre as Hill's assessment (1974) gives us to understand.

Scientists visiting Nymph Is, mainly to solve geomorphological questions, incidentally quoted a few physiognomic species such as *Sesuvium* (Steers 1937). Stoddart was the fist, however, to systematically record the species he came across. At the time (1973) of the Royal Society - Universities of Queensland Expedition, he collected 1107 specimens on forty islands and listed 19 others on sight. Thus according to the records (Fosberg & Stoddart 1991), an inventory of 24 plant species in 23 families was made on Nymph. Twenty-two were registered on sight only while two marine phanerogams were collected: *Halophila minor* (number 4739) and *Zostera capricorni* (number 4792).

Fosberg and Stoddart's (1991) compilation also included the collections made by Heatwole on Nymph in 1984. Thirty-eight species were collected of which twelve had already been sighted by Stoddart in 1973 along 26 new ones. All of them are deposited in the Queensland Herbarium. If we take Heatwole's compilation into account, we can say that the richness of Nymph flora amounted to fifty species at that time, although eleven of the 24 species noted by Stoddart were not seen again by Heatwole.

2.2. Annotated checklist

Plant families are arranged in alphabetical order without consideration of their usual allocation to Dicots or Monocots classes. Families are those admitted by Brummitt (1992) with three exceptions: Avicenniaceae are included here within Verbenaceae, Leguminosae are split into three families (Caesalpiniaceae, Fabaceae and Mimosaceae) and Sonneratiaceae are rooted of Lythraceae. Within each family, the genera are listed in alphabetical order as are the species within the genus.

Specimens are held either in the Queensland Herbarium, Brisbane, or in the private collection of the first author.

If needed, details are provided for each species under headlines of synonymy, frequency on the island, phenological data (flowering and/or fruiting periods) and habitat. Phenology

("Flowering" or "Fruiting") is biased as we could only register data during our stays i.e. during August – September (spring) and December – February (autumn). Descriptions of the taxa are not given but comments on specialized classification problems or on previous data are suggested.

Synonyms are provided only in cases where recent nomenclature change has adjusted the one adopted by Fosberg & Stoddart (1991).

Signs and abbreviations
(before or after plant names)
* taxon new for Nymph Island
** taxon new for coral cays of the northern section of GBR
< taxon collected before 1990 and not seen between then and 1997
[s]: seadrifted species
[w]: a weed or introduced

Frequency
given on a 3-level scale (records as they appear in the vegetation relevés, see Part 3):
frequent : > 10 records
infrequent: 4-10 records
rare : 1 - 3 records

AGAVACEAE

< ***Pleomele angustifolia*** (Medikus) N.E.Br.
(syn.: *Dracaena angustifolia* Roxb.)
Comments: a native of the GBR noted down on sight by Stoddart (1973) but not seen or collected again neither by Heatwole (1984) nor on our visits between 1990 and 1997.

AIZOACEAE

Sesuvium portulacastrum (L.) L. [s]
Frequency: frequent. **Flowering**: February. **Habitat**: on conglomerate platforms irregularly inundated by tides or among succulent mats regularly flooded; occasionally in mangroves and in *Pemphis* shrub.
Comments: The first plant species recorded fmph (Steers 1937)

AMARANTHACEAE

Achyranthes aspera L. [w]
Frequency: infrequent. **Habitat**: sandy open places or on coral rubble in the tussock *Lepturus* grassland.

* ***Amaranthus interruptus*** R.Br. [w]
Frequency: rare. **Habitat**: under *Casuarina* woodland.

ANNONACEAE

* ***Polyalthia nitidissima*** (Dunal) Benth.
Frequency: frequent. **Flowering**: January-February. **Habitat**: central *Manilkara* forest and associated shrubland.
Comments: among the GBR coral cays only known from Green Is.

APOCYNACEAE

* ***Alyxia spicata*** R.Br.
Frequency: rare. **Habitat**: open strand shrub communities.

* ***Carissa laxiflora*** Benth.
Frequency: frequent. **Flowering**: floral buds in mid August; flowering: February. **Habitat**: open *Casuarina* woodland and central *Manilkara* forest.

ARALIACEAE

* ***Schefflera actinophylla*** (Endl.)Harms
Frequency: only once recorded (1992) as a sterile individual. **Habitat**: open *Casuarina* woodland.

ARECACEAE

Cocos nucifera L. [w]
Comments: Probably introduced by the first settlers; the last tree still present in 1990, dead in 1993.

ASCLEPIADACEAE

* ***Cynanchum carnosum*** (R.Br.) Schltr.
(Syn.: *Ischnostemma carnosum* (R.Br.) Merr. & Rolfe)
Frequency: infrequent. **Flowering**: August through February. **Habitat**: climbing on shrubs in the *Pemphis* community and in mangroves.
Comments: The census of Fosberg & Stoddart (1991) makes a distinction between *Cynanchum carnosum* and *Ischnostemma carnosum*.

** ***Hoya oligotricha*** K.Hill subsp. **oligotricha**
Frequency: frequent. **Flowering**: August. **Habitat**: a common twiner in central *Manilkara* forest and as a vine tangling the thicket.
Comments: Flora Australis (vol. 28) does not recognize *H. oligotricha* which is synonymized with *H. australis* R.Br. subsp. *australis*. This last taxon has only been collected from Two Isles (Stoddart 4622, 4652, in: Fosberg & Stoddart 1991).

Sarcostemma australe R.Br.
Frequency: frequent. **Flowering**: September. **Habitat**: vine thicket on coral rubble levees or even on pumice piling up at rear of high coral ridges, also in open shrubland on the cay.

ASTERACEAE

* ***Bidens bipinnata*** L. [w]
Comments: a worldwide weed once collected in 1990.

< ***Emilia sonchifolia*** (L.) DC. [w]
Frequency: once collected in 1984.
Comments: an annual weed native to tropical Africa.

Melanthera biflolia (L.) Wild. [s]
(syn.: *Wedelia biflora* (L.) DC.)
Frequency: infrequent. **Flowering**: August to February. **Habitat**: mainly in tussock grassland on high coral rubble levees.

< ***Vernonia cinerea*** (L.) Less. [w]
Frequency: once collected in 1984
Comments: a weed native to Central America.

BATACEAE

* ***Batis argillicola*** P.Royen (fig. 19)

Frequency: rare. **Flowering**: August. **Fruiting**: February. **Habitat**: at the exit and along the tidal channel to the central lagoon, on sandy substratum of the *Lumnitzera* mangrove and in clearings of the *Bruguiera-Ceriops* mangrove.

BORAGINACEAE

Argusia argentea (L.f.) Heine [s]

(syn.: *Messerschmidia argentea* (L.f.) I.M.Johnst.)

Frequency: infrequent. **Flowering**: August-September. **Habitat**: upper-shore pioneering community; open *Casuarina* woodland.

* ***Cordia subcordata*** Lam. [s]

Frequency: rare. **Habitat**: *Casuarina* woodland.

CAESALPINIACEAE

* ***Caesalpinia bonduc*** (L.) Roxb. [s]

Frequency: rare. **Habitat**: within *Pemphis* shrub.

* ***Lysiphyllum hookeri*** (F.Muell.) Pedley

(Syn.: *Bauhinia hookeri* F.Muell.)

Frequency: rare, only once collected. **Habitat**: within *Pemphis* shrub.

CAPPARACEAE

* ***Capparis lucida*** (DC.) Benth.

Frequency: frequent. **Flowering & fruiting:** August-September. **Habitat**: vine thicket and open *Casuarina* forest.

* ***Capparis quiniflora*** DC.

Frequency: rare. **Flowering**: February. **Habitat**: central vine thicket.

* ***Capparis sepiaria*** L.

Frequency: infrequent. **Flowering**: September to February. **Fruiting**: January-February. **Habitat**: understorey shrub or climbing high in the central *Manilkara* forest.

* ***Cleome viscosa*** L. [w]

Frequency: frequent. **Flowering**: February. **Fruiting**: August-September. **Habitat**: on disturbed sandy site near the camping area and under open *Casuarina* woodland .

CASUARINACEAE

Casuarina equisetifolia L. subsp. ***incana*** (Benth.) L.Johnson

Frequency: Frequent. **Habitat**: *Casuarina* woodland on the cay; also on coral rubble ridges.

Comments: Some of the collected specimens show intermediate characteristics and signs of introgression with *Casuarina equisetifolia* subsp. *equisetifolia* notably with their phyllichnia predominantly and prominently angular. The key provided by Wilson & Johnson (1989) does not work well on the intermediate forms found from Lizard Island area: according to Batianoff (in litt.) no one character provided can be used with any confidence. That part of Queensland indeed is situated on the southern limit of expansion of subsp. *equisetifolia* and northern limit of subsp. *incana*.

CELASTRACEAE

* ***Cassine melanocarpa*** (F.Muell.) Kuntze

(syn.: *Elaeodendron melanocarpum* F.Muell.)

Frequency: frequent. **Flowering**: February. **Fruiting**: August. **Habitat**: central *Manilkara* forest and associated shrubland.
Comments: the frequency of *C. melanocarpa* in the central forest contrasts with its relative infrequency in the northern Australian states where it is recorded in the Wide Bay district (south-eastern QLD), on the W.Australia northern coast and islands and in Northern Territory.

** ***Pleurostylia opposita*** (Wallich) Alston
Frequency: rare. **Flowering & fruiting**: December-January. **Habitat**: fringes of the central *Manilkara* forest.

CHENOPODIACEAE

< ***Halosarcia halocnemoides*** (Nees) P.G. Wilson
Comments: a native only once recorded in 1984 (Heatwole number 133)

Halosarcia indica (Willd.) P.G.Wilson subsp. ***leiostachya*** (Benth.) P.G.Wilson
Frequency: infrequent. **Habitat**: succulent mats on the inner zone of the low platform not flooded at every tide.
Salsola kali L.
Frequency: rare. **Habitat**: on stabilized sand of the upper-shore.

Sarcocornia quinqueflora (Ung.-Sternb.) A.J.Scott subsp. ***quinqueflora***
Frequency: frequent. **Habitat**: succulent mats on conglomerate platform regularly flooded by tides: among *Sporobolus* herbland on stormlashed platforms in front of *Pemphis* shrubs.

* ***Suaeda australis*** Moq.
Frequency: frequent. **Habitat**: succulent mats from the most inner reef flats to higher on conglomerate platform regularly flooded at each tide.

<***Tecticornia australasica*** (Moq.) P.G.Wilson
(syn.: *Salsola cinerea* (F.Muell.) F.Muell.)
Comments: a native species only once recorded in 1984 (Heatwole number 119).

COMBRETACEAE

* ***Lumnitzera racemosa*** Willd.
Frequency: infrequent. **Flowering**: February. **Habitat**: mangrove of its own (with *Excoecaria*) or as understorey of the *Bruguiera-Ceriops* mangrove.
Comments: According to Stoddart (1980) *L. racemosa* is infrequent on northern GBR cays being recorded only on Pipon Is. while Fosberg & Stoddart (1991) mention it on ten or so islands.

* ***Terminalia muelleri*** Benth.
Frequency: frequent. **Fruiting**: August. **Habitat**: *Manilkara* monsoon forest and open *Casuarina* woodland

COMMELINACEAE

Commelina undulata R.Br.
Frequency: infrequent. **Flowering**: August. **Habitat**: in tussock grassland on coral rubbles.

CONVOLVULACEAE

** ***Evolvulus alsinoides*** L.
Frequency: rare. **Flowering**: August-September. **Habitat**: open sandy places within the vine thicket.

Ipomoea macrantha Roem. & Schult. [s]
Frequency: infrequent. **Flowering**: August-September through February. **Habitat**: scrubby tussock grassland on old coral rubble ridges.

* ***Ipomoea pes-caprae*** (L.) R.Br. subsp. ***brasiliensis*** (L.) Ooststr. [s]
Frequency: infrequent. **Flowering**: August-September through February. **Habitat**: on freshly deposited sand, pioneering foredune herbfield; also on coral rubble in the *Lepturus* tussock grassland.

< ***Operculina turpethum*** (L.) S.Manso
Comments: only once collected (Heatwole 1984).

* ***Xenostegia tridentata*** (L.) Austin & Staples
Frequency: rare. **Flowering**: August-September. **Habitat**: open sandy places.

CUCURBITACEAE

* ***Diplocyclos palmatus*** (L.) C.Jeffrey subsp. ***affinis*** (Endl.) P.S.Green
Frequency : rare. **Fruiting**: August -September. **Habitat**: open places in vine thicket

* ***Mukia maderaspatana*** (L.) M.Roemer
Frequency: rare. **Flowering** : September to February. **Habitat**: on old coral rubble ridges

CYMODOCEACEAE

* ***Cymodocea rotundata*** (Hempr. & Ehrenb) Asch. & Schweinf.
Frequency: rare. **Habitat**: inner reef flat.

* ***Halodule pinifolia*** (Miki) Hartog
Frequency: rare. **Habitat**: inner reef flat.

* ***Halodule uninervis*** (Forsskal) Asch.
Frequency: infrequent. **Habitat**: inner reef flat.

CYPERACEAE

* ***Bulbostylis barbata*** (Rottb.) C.B.Clark [s]
Frequency: frequent. **Flowering**: August. **Habitat**: forming monospecific patches on sandy open places and under open *Casuarina* woodland; secondarily in open tussock grassland on coral rubble ridges.

* ***Cyperus pedunculatus*** (R.Br.) Kern [s]
(syn.: *Remirea maritima* Aublet)
Frequency: rare. **Habitat**: sandy mound edging a mangrove.
Comment: as well as *R. maritima* Aublet, Fosberg & Stoddart (1991) take down *C. pedunculatus* F.v.M. which could be either a misspelling for *C. pedunculosus* F.Muell. or a wrong author name?

* ***Cyperus scaber*** (R.Br.) Boeckeler
Frequency: rare. **Fruiting**: February. **Habitat**: tussock grassland on coral rubble ridges.

** ***Cyperus tetracarpus*** Boeckeler
Frequency: rare. **Fruiting**: February. **Habitat**: sandy open places in central shrubland and on sandy mounds within *Lumnitzera* mangrove.

DIOSCOREACEAE

** ***Dioscorea bulbifera*** L.
Frequency: rare. **Habitat**: central *Manikara* forest.

** ***Dioscorea transversa*** R.Br.
Frequency: rare. **Flowering**: January-February. **Habitat**: open shrubland.

EBENACEAE

* ***Diospyros compacta*** (R.Br.) Kostermans
(Syn.: *D. ferrea* (Willd.) Bakh. var. *reticulata* (R.Br.) Bakh.)
Frequency: rare. **Flowering** & **fruiting**: February. **Habitat**: open shrubland on stabilized upper-shore.

* ***Diospyros maritima*** Blume
Frequency: infrequent. **Flowering**: February. **Fruiting**: September. **Habitat**: central vine thicket and *Manilkara* forest.

EUPHORBIACEAE

* ***Breynia oblongifolia*** (Muell.Arg.) Muell.Arg.
Frequency: rare. **Fruiting**: February. **Habitat**: open vine thicket.

* ***Drypetes lasiogyna*** (F.Muell) Pax & K.Hoffm. var. ***australasica*** (Muell.Arg.) Airy Shaw
Frequency: frequent. **Flowering**: September. **Fruiting**: January. **Habitat**: central *Manilkara* forest and vine thicket.
Comments: leaf size and form quite variable; margins entire, crenate to dentate and even sharply toothed on juvenile plants.

* ***Euphorbia atoto*** G.Forst. [s]
Frequency: rare. **Flowering**: August through February. **Habitat**: upper-strand pioneering community.

* ***Euphorbia hirta*** L. [w]
Frequency: rare. **Habitat**: on open sand.
Comments: only once recorded (1995), a transient weed native to Central America.

Euphorbia tannensis Sprengel
Frequency: infrequent. **Flowering**: August-September. **Fruiting**: January-February. **Habitat**: mainly under *Casuarina* woodland; also in foredune pioneering community.

Excoecaria agallocha L.
Frequency: infrequent. **Habitat**: in *Lumnitzera* mangrove and at edges of mangrove on coral ramparts, exceptionally flooded.

* ***Phyllanthus novae-hollandiae*** Muell.-Arg.
Frequency: rare. **Fruiting**: February. **Habitat**: open vine thicket.

FABACEAE

* ***Abrus precatorius*** L.
Frequency: infrequent. **Fruiting**: July-August. **Habitat**: open *Casuarina* woodland.

* ***Canavalia rosea*** (Sw.) DC. [s]
Frequency: frequent. **Fruiting**: August-September. **Habitat**: mainly in tussock grassland on coral rubble; also in foredune plant community.

< ***Crotalaria linifolia*** L.f.
Frequency: transient as annual, only once collected in 1984.

* ***Macroptilium atropurpureum*** (DC.) Urb. [w]
Frequency: rare, once collected in open *Pemphis* shrub
Comments: a noxious weed native to tropical America. The first invaders of that weed were noticed on Nymph Is in the 1990's.

* ***Pongamia pinnata*** (L.) Pierre [s]
Frequency: rare (a few sterile individuals). **Habitat**: open shrubland at edges of the *Casuarina* woodland.

* ***Rhynchosia minima*** DC.
Frequency: infrequent. **Flowering**: August-September. **Habitat**: herbfields on coral rubble, open sandy places in central shrubland.

* ***Sophora tomentosa*** L. [s]
Frequency : rare. **Habitat** : as a juvenile in upper-strand community.

Vigna marina (Burm.f.) Merr. [s]
Frequency : rare. **Flowering** : August. **Habitat**: upper strand community.

FLACOURTIACEAE

** ***Scolopia braunii*** (Klotsch) Sleumer
Frequency: infrequent. **Habitat**: central *Manilkara* forest and associated shrubland
Comment: first report on a coral island.

FLAGELLARIACEAE

Flagellaria indica L.
Frequency: infrequent. **Flowering**: August. **Habitat**: edges of mangrove, on coral ridges, also in open vine thicket.

GOODENIACEAE

* ***Scaevola sericea*** Vahl [s]
(syn.: *S. taccada* (Gaertn.) Roxb.)
Frequency: infrequent. **Flowering**: August-September. **Habitat** : open *Casuarina* woodland

HYDROCHARITACEAE

Halophila minor (Zoll.) Hartog
(syn.: *Halophila ovata* Gaudich.)
Frequency: frequent. **Habitat**: on the inner reef flat.
Comments : The legitimacy of separating this taxon from *H. ovalis* has been frequently questionned. The problem in particular arises during field samplings : being difficult to separate both taxa are therefore frequently reported under *H. ovalis* (Bridges & al. 1982, Lee Long & al. 1989)

* ***Halophila ovalis*** (R.Br.) J.D.Hook
Frequency: rare. **Habitat**: on the inner reef flat.

Thalassia hemprichii (Ehrenb.) Asch. (fig. 15)
Frequency: frequent. **Habitat**: on the inner reef flat.

LAURACEAE

< ***Cassytha filiformis*** L. [s]
Comments: This species has been reported by Heatwole (s.n.) and by Stoddart (on sight); no specimens being available, these data must be regarded as doubtful and could probably be assigned to *C. pubescens*.

< ***Cassytha glabella*** R.Br. [s]
Comments: Heatwole 142 (?) (in Fosberg & Stoddart 1991). According to the Census (Hnatiuk 1990), *C. glabella* would be out of its range in northern Queensland and its presence ought to be confirmed.

* ***Cassytha pubescens*** R.Br. [s]
Frequency : frequent. **Flowering** & **fruiting** : throughout August-September. **Habitat**: tussock grassland on coral rubble ridges and in vine thicket.
Comments: All the specimens we collected are to be assigned to this species which formerly has been recorded on the nearby Turtell II by Buckley (number 3369).

LYTHRACEAE

Pemphis acidula J.R.Forst. & G.Forst. [s]
Frequency: frequent. **Flowering**: January-February. **Habitat**: on sandy beach foreshores but also on coral rock levees or ridges around moats and on high rock platforms. Their extremely hard wood allow their powerful stems and roots to reach the water level clearly below their sometimes apparently dry substratum. When this one is swept away by storms they may stay alive anchoring lonely on beaches where they stand up straight as small trees with unusual twisted trunks (fig. 23).

MALVACEAE

Abutilon asiaticum (L.) G.Don var. **australiense** (Hoch. ex Britt.) Fosberg
(syn.: *A. indicum* (L.) Sweet var. *australiense* Britt.)
Frequency: infrequent, apparently transient. **Flowering**: August. **Habitat**: openings in strand shrub communities.
Comments: Fosberg & Stoddart (1991) recorded the taxon as *A. asiaticum* Miquel: origin of that unusual reference could not be uncovered.

* ***Hibiscus tiliaceus*** L. [s]
Frequency: rare and sterile. **Habitat**: *Casuarina* woodland.

* ***Thespesia populnea*** (L.) Sol. ex Correa [s]
Frequency: rare and sterile. **Habitat**: mixed *Pemphis* shrub.

MELIACEAE

* ***Aglaia elaeagnoidea*** (A.Juss.) Benth.
Frequency: frequent. **Fruiting**: January. **Habitat**: central *Manilkara* forest and *Casuarina* open woodland.

* ***Vavaea amicorum*** Benth. (fig. 14).
(syn.: *V. australiana* S.T.Blake)
Frequency: infrequent. **Flowering** & **fruiting**: January-February. **Habitat**: central *Manilkara* forest and *Casuarina* woodland.

* ***Xylocarpus moluccensis*** (Lam.) M.Roemer
(syn. : *X. australasicus* Ridley, *X. mekongensis* Pierre)
Frequency: rare. **Habitat**: *Rhizophora* mangrove, central lagoon northern bank.
Comment: the collected specimen lacking flowers or fruits was assigned to *X. moluccensis* with the help of bark features. Like Percival & Womersley (1975), Fosberg & Stoddart (1991) still uphold *X. australasicus* splitted from *X. moluccensis*

MENISPERMACEAE

* ***Tinospora smilacina*** Benth
Frequency: rare. **Flowering**: January-February. **Habitat**: open shrubland

MORACEAE

* ***Ficus microcarpa*** L.f. var. **hillii** (Bailey) Corner
Frequency: rare. **Fruiting**: February. **Habitat**: *Casuarina* open woodland and associated shrubland.

Ficus opposita Miq.
Frequency: infrequent. **Habitat**: scrubby tussock grassland on old coral rubble ridges.

* ***Malaisia scandens*** (Lour.) Planchon
Frequency: infrequent. **Flowering**: September to February. **Habitat**: scrubland on coral rubble

MYOPORACEAE

Myoporum acuminatum R.Br.
Frequency: frequent. **Flowering**: August-September. **Habitat**: scrubby tussock grassland on old coral rubble ridges; *Casuarina* woodland and central open shrubland.

MYRTACEAE

* ***Eugenia reinwardtiana*** (Blume) DC.
Frequency: frequent. **Fruiting**: August-September. **Habitat**: central *Manilkara* forest but mainly in associated shrubland.

Osbornia octodonta F.Muell.
Frequency: infrequent. **Flowering**: February. **Habitat**: in different mangroves communities but forming its own kind of mangrove; secondarily in succulent mats as juveniles.

NYCTAGINACEAE

* ***Boerhavia albiflora*** Fosberg
Frequency: frequent. **Flowering**: August-September. **Habitat**: tussock grassland on coral rubble ridges and under open *Casuarina* woodland.
Comments: Meikle & Hewson (1984) included this species in a broadly circumscribed *B. tetrandra* G.Forst. while according to Fosberg (1988) the latter species should be considered as a Pacific Islands taxon absent from Australia and neighbouring islands.

* ***Boerhavia glabrata*** Blume
Frequency: infrequent. **Flowering**: August-September. **Habitat**: tussock grassland.
Comments: One of the species accepted within the *Boerhavia repens* group by Fosberg (1988) but regarded as a synonym of *B. diffusa* by Meikle & Hewson (1984). According to Du Puy & Telford (1993) a species complex involving also *B. mutabilis* R.Br.

= ***Boerhavia mutabilis*** R.Br.
Comments: Fosberg (1988) assigned provisionally the specimen collected in 1984 by Heatwole (Heatwole number 136) to that taxon which is a synonym of *B. coccinea* Miller.

OLEACEAE

** ***Chionanthus ramiflora*** Roxb
Frequency: frequent. **Flowering**: January-February. **Fruiting**: August. **Habitat**: central *Manilkara* forest and associated shrubland.

* ***Jasminum aemulum*** R.Br
Frequency: rare. **Flowering**: August. **Habitat**: openings in strand shrub communities.

OPILIACEAE

* ***Opilia amentacea*** Roxb
Frequency: infrequent. **Flowering**: July-August. **Habitat**: central *Manilkara* forest and vine thicket.

ORCHIDACEAE

* ***Dendrobium discolor*** Lindley

Frequency: rare. **Flowering**: August. **Habitat**: central vine thicket.

** ***Geodorum neocaledonicum*** Kraenzlin

Frequency: rare. **Flowering**: January. **Habitat**: under the cover of the central shrubland.

PANDANACEAE

* ***Pandanus tectorius*** Parkinson [s]

Frequency: rare. **Habitat**: upper-shore vine thicket.

PASSIFLORACEAE

Passiflora foetida L. [w]

Frequency: infrequent. **Flowering**: August-September. **Habitat**: mainly tussock grassland on coral rubble levees.

Comments: a weed native to South America, apparently naturalized on Nymph.

PLUMBAGINACEAE

Aegialitis annulata R.Br.

Frequency: infrequent. **Flowering**: September. **Habitat**: As a slender shrub 2 m high on exposed seaward edge of mangrove with *Avicennia* or in monospecific populations, namely on the conglomerate platform on southern islet or below the cliff of the high platform; as a small tree (4-5 m high) within mangroves on the rear of the old moat.

POACEAE

** ***Eragrostis interrupta*** (R.Br.) P.Beauv.

Frequency: rare. **Habitat**: open sandy glades within the central shrubland.

Lepturus repens (G.Forst.) R.Br. [s]

Frequency: frequent. **Flowering**: July-August. **Habitat**: tussock grassland on coral rubble and under dense *Casuarina* woodland.

** ***Sorghum plumosum*** (R.Br.) P.Beauv.

Frequency: rare. **Flowering**: August. **Habitat**: on open sandy places like stabilized uppershore or on higher terraces within open shrubland.

Sporobolus virginicus (L.) Kunth

Frequency: frequent. **Flowering**: August-September. **Habitat**: on sand flooded or sprayed with sea water at regular intervals even on shallow deposits on conglomerate platforms, either in *Lumnitzera* mangroves or in succulent mats, less frequent and often sterile on dry open sand under *Casuarina* woodland.

Comments: reported from most coral islands of the northern section of the GBR.

* ***Themeda*** sp.

Frequency: only once collected on Nymph, in openings of the shrubland in 1993.

* ***Thuarea involuta*** (G.Forst.) R.Br. ex Roem. & Schult. [s]

Frequency: infrequent. **Flowering**: August. **Habitat**: under the cover of *Casuarina* woodland, never found among the pioneering species on the front-shore.

PORTULACACEAE

* ***Portulaca australis*** Endl.

Frequency: rare. **Flowering**: August-September through February. **Habitat**: under *Casuarina* woodland and on coral rubble.

RHAMNACEAE

Colubrina asiatica (L.) Brongn.
Frequency: infrequent. **Habitat**: on stabilized sand of upper-shore and on higher terraces in *Casuarina* woodland.

RHIZOPHORACEAE

Bruguiera exaristata Ding Hou
Frequency: frequent. **Fruiting**: September. **Habitat**: on the back of mangroves or in exceptionally flooded mangroves.
Comments: Surprisingly this is the only *Bruguiera* species we could detect on Nymph Is while *B. gymnorhiza* looks more frequent on the GBR northern cays like on the nearby Turtell V Is.

****Ceriops tagal*** (Perr.) C.B.Robinson var. **tagal**
Frequency: infrequent. **Fruiting**: September. **Habitat**: in inner mangrove flooded by occasional flows.

Rhizophora stylosa Griffith
Frequency: frequent. **Flowering**: January-February. **Fruiting**: August-September. **Habitat**: on sandy or muddy shores of the central lagoon or surrounding smaller lagoons; along the conglomerate high platform and in moats.

RUBIACEAE

* ***Canthium coprosmoides*** F.Muell.
Frequency: rare. **Fruiting**: January-February. **Habitat**: as an understorey shrub in *Casuarina* woodland.

** ***Canthium odoratum*** (G.Forst.) Seeman
Frequency: rare. **Flowering**: December. **Fruiting**: January-February. **Habitat**: central shrubland.
Guettarda speciosa L. [s]
Frequency: rare. **Habitat**: *Pemphis* shrub; scrubby tussock grassland on coral rubble.

Ixora timorensis Decne.
(syn.: *I. klanderiana* F.Muell.)
Frequency: infrequent. **Flowering**: September. **Habitat**: central *Manilkara* forest and associated shrubland.

** ***Psychotria daphnoides*** Cunn. ex Hook.
Frequency: rare. **Flowering & fruiting**: February. **Habitat**: central shrubland.

** ***Psychotria nesophila*** F.Muell.
Frequency: rare. **Flowering**: September. **Habitat**: as an understorey shrub in *Casuarina* woodland.

RUTACEAE

* ***Glycosmis pentaphylla*** (Retz.) DC.
Frequency: infrequent. **Fruiting**: February. **Habitat**: central *Manilkara* forest.

Micromelum minutum (G.Forst.) Wight & Arn.
Frequency: frequent. **Flowering**: January-February. **Fruiting**: January-February. **Habitat**: *Casuarina* open woodland.

SANTALACEAE

* ***Exocarpos latifolius*** R.Br
Frequency: rare. **Flowering**: February. **Habitat**: open to closed shrubland.

SAPINDACEAE

** ***Alectryon connatus*** (F.Muell.) Radlk.

Frequency: rare. **Habitat**: central *Manilkara* forest.

SAPOTACEAE

Manilkara kauki (L.) Dubard

Frequency: frequent. **Flowering**: February (all trees simultaneously start upon their flowering and the whole island fills with a strong sweet smell during a couple of days). **Fruiting**: August-September. **Habitat**: central *Manilkara* forest and vine thicket.

Mimusops elengi L.

Frequency: frequent. **Flowering**: February. **Fruiting**: August. **Habitat**: under *Casuarina* open woodland; secondarily under central *Manilkara* forest and associated shrubland.

Planchonella obovata (R.Br.) Pierre

Frequency: frequent. **Flowering**: February. **Habitat** : under *Casuarina* open woodland; secondarily under central *Manilkara* forest.

SONNERATIACEAE

* ***Sonneratia alba*** Smith

Frequency: rare. **Fruiting**: September. **Habitat**: *Rhizophora* mangrove along the satellite islet.

SURIANACEAE

Suriana maritima L. [s]

Frequency: frequent. **Flowering**: August-September through February. **Habitat**: in the understorey of the *Casuarina* woodland; strand shrub communities.

TACCACEAE

* ***Tacca leontopetaloides*** (L.) Kuntze [s]

Frequency: rare. **Flowering**: August-September. **Habitat**: open sandy places in vine thicket.

TILIACEAE

* ***Grewia oxyphylla*** Burret

Frequency : infrequent. **Flowering**: February. **Fruiting**: September. **Habitat**: scrubby *Lepturus* grassland on coral rubble ridges.

ULMACEAE

* ***Celtis philippensis*** Blanco

Frequency : frequent **Flowering** : August-September **Fruiting**: February. **Habitat**: *Pemphis* thicket; central woodland and associated shrubland.

Comments: Frequently misspelt as *C. philippinensis*.

VERBENACEAE

* ***Avicennia marina*** (Forsskal) Vierh. var. ***australasica*** (Walp.) Mold.

Frequency : frequent **Flowering** : September **Fruiting** : January-February. **Habitat**: as a shrub or a small tree in exposed situations on the western reef flat as well as on southern conglomerate platform; as a tree in the mangrove fringing the central lagoon.

* ***Clerodendron inerme*** (L.) Gaertner [s]

Frequency : rare **Flowering** : from August to February **Habitat** : fringe of mangrove on coral ridge

* ***Premna serratifolia*** L.
Frequency: frequent. **Habitat**: stabilized upper-shore, particularly under the *Casuarina* woodland, far less represented on higher terraces in the vine thicket.

* ***Vitex ovata*** Thunb. [s]
Frequency: rare. **Habitat**: pioneering fore-dune herbfield.

****Vitex trifolia*** L. var. ***subtrisecta*** (Kuntze) Moldenke
Frequency : infrequent. **Flowering** : August and February. **Habitat**: scrubby *Lepturus* grassland on high coral ridges.

VITACEAE

* ***Cayratia cardiophylla*** B.R.Jackes
Frequency: rare. **Habitat**: exclusive of the open vine thicket.
Comment: the only reports of *C. cardiophylla* from coral islands are due to Walker (1991) as mentioned by Fosberg & Stoddart (1991) who seem unaware of the revision of the genus *Cayratia* by Jackes (1987). Thus their survey of *Cayratia* species distribution cannot be taken into account all the more since *C. cardiophylla* has been till recently misidentified as *C. grandifolia* (Warb.) Merr. & Perry.

** ***Cayratia maritima*** B.R.Jackes
Frequency: rare, apparently transient. **Habitat**: on coral rubble levee, an apparently unusual habitat according to Jackes (1987).
Comment: only once collected in 1990; the sterile specimen was readily affected to *C. maritima* on the basis of the tendrils lacking adhesive pads and the glabrous mature leaves with hooked hairs on the adaxial midrib.

Cayratia trifolia (L.) Domin
Frequency: infrequent. **Flowering & fruiting**: January-February. **Habitat**: either climbing onto shrubs (mainly *Pemphis*) or sprawling among herbs in the *Lepturus* tussock grassland.

ZOSTERACEAE

Zostera capricorni Asch.
Frequency: rare. **Habitat**: on the reef flat.

ZYGOPHYLLACEAE

Tribulus cistoides L. [w]
Frequency: rare, transient. **Flowering & fruiting**: August to February. **Habitat**: open sandy places on the cay.
Comments: a tropical weed native to Central America.

2.3. State-of-the-art of the knowledge of the flora

By the end of our study, the total number of species, collected or observed on Nymph, increased threefold the amount quoted in Fosberg & Stoddart's (1991) compilation. The checklist now comes to 143 species in 63 families i.e. one third of the known flora on coral islands of the northern GBR. These high-density figures are a feature of the island's ecosystem.

In contrast, the number of species and genera for the number of families appears quite low: a mean of just over 2.2 species (generic index) and of 1.9 genera per family while

for most continental flora the proportion exceeds 10 species per family. Equivalent figures (respectively 2.6 and 2.1) are valid for Green Is, a pure sand cay with similar floristic richness (Neil 2000). Yet, on the Australian mainland in the Kimberley (W Australia) e.g., an area of some 300,000 km^2, Wheeler (1992) recorded a mean of more than twelve species and more than three genera per family.

On checking of all the collated species, we found that 93 of them are reported here for the first time on Nymph Island (in the checklist their names are preceded by an asterisk). Moreover, fifteen of these species are new for the northern section of the GBR (**). These outcomes make Nymph Island one of the richest GBR islands. However, of the 48 species reported by Stoddart or Heatwole, eight species were not seen any more (<); most of them are transient species for example *Emilia sonchifolia* or *Crotalaria linifolia*.

Any comparison on floristic richness with other cays remains difficult. The diversity of habitats on islands such as Nymph with its extended mangroves, saline meadows, long-lasting stabilized cay and old shingle levees cannot be paralleled with an exclusively sandy and intensively visited cay like Green Island (Neil 2000). A sound comparison can only be made with a coral island of about the same age, the same habitat diversity and roughly equivalent climatic conditions, in our case other 'low wooded islands' of the northern GBR. Compilation by Fosberg & Stoddart (1991) for Low Isles and Three Isles showed that for now floristic diversity on Nymph Island is about twice that of other well-investigated islands. It also showed the great number of species, respectively 58 and 53, that those 'low wooded islands' have in common with Nymph.

The frequency of the species observed as expressed in the number of occurrences in the vegetation relevés as a whole (cf. Part 3) are also instructive. Out of the 143 species reported on Nymph at the present time, half of them are regarded as rare i.e. mostly noticed only once. Note, however, that of the seventy more or less frequent species, some that are easily identifiable like *Scaevola taccada* have astonishingly never been reported before; among the frequent species, some fifteen are reported here as new for Nymph Is, while some like *Avicennia marina* or *Hoya oligotricha* could have been spotted relatively easily; others like *Aglaia elaeagnoidea, Cassine melanocarpa, Chionanthus ramiflora, Drypetes lasiogyna* and *Vavaea amicorum* (fig. 14) which play a major role in the central woodland could have been more difficult to pick out on the grounds of their apparently trivial appearance. These findings are hard to understand and cast some doubt on earlier surveys.

Some species have not been detected on Nymph and yet their presence was highly probable. *Bruguiera gymnorhiza* was not found although it is exclusive to some mangroves on nearby cays like Turtell Island V. Other species frequently reported from GBR cays like *Cordia subcordata* or *Sophora tomentosa* are poorly represented on Nymph as their fundamental niche is barely established in the present evolutionary stage of the cay.

The ratio of alien or of introduced plant species to the whole flora is a good indicator of the status of a given territory. For example, Heron Island, which is a much visited cay, has a ratio of 0.25[1] (sixteen alien and introduced species out of a total of 64) while for Nymph, remote and quiet, the ratio is less than 0.10. However that may be, most of the 'accidental' weedy species on coral islands (like *Macroptilium atropurpureum*) seem to

[1] According to Stoddart & Fosberg (1991), those figures are still higher: they come to 26 introductions for a total of 51 species!

spread through bird dispersal (Heatwole 1989). Land birds (like Fruit-Doves) or sea birds (like Silver gulls), important visitors to Nymph Is eastern cay and western shingle ridges (Smith 1994), are known to transport fruits and seeds from island to island. Nevertheless, when speaking about the conquest of a new land, the pattern of extinction of the aliens introduced are determinant factors and that pattern largely based on the proportion of disturbed or modified habitat, a factor which accounts for little on Nymph Is.

These results also show that most of the reports on the floristic richness of the coral cays were carried out on the basis of plant size, and were therefore inadequate where widely unrecognised flora was concerned.

Figure 2. The eastern reef flat at low tide from its outer edge with boulders in the foreground and, in the background, the strand topped by Casuarina equisetifolia *woodland*

Figure 3. Northeastern sand cay showing upper beach with Scaevola taccada *on the right-hand side and* Casuarina equisetifolia *on the left*

Figure 8. Rhizophora mangle seedlings in the mud bed on the southern side of the bridge (approximately 200 m from the outer edge of mud) (© J. Lovelock).

Figure 9. In the foreground Avicennia germinans seedlings on open mud. In the background, to the left and the upper platform with Pteroplatea micrura (© J. Lovelock). Rhizophora trees on the right.

Figure 8 – Mud mound 2 undercut by Rhizophora *spp.* and Sarcocornia quinqueflora *succulents on the low platform. To the left foreground* Pempheris schomburgkii *fish (12 to 20 cm standard length).*

Figure 9 – The mound complex from the landward side.

Figure 10 – The northern branch of the channel emerging from the central lagoon (in the background). To the left Rhizophora stylosa *mangal and to the extreme right* Osbornia octodonta *mangal on the banks between the channels.*

Figure 11 – The southernmost mouth of Dhow Creek (left) [illegible] the [illegible] mangal on the right and a mangal dominated by Rhizophora stylosa.

Figure 12. Succession of mosquito-infested *Eucalyptus* with *Acacia* annuals, shrubs to the right. In the background moat nr 2 surrounded by *Rhizophora* stands.

Figure 14. Vavaea amicorum *(Meliaceae) flowering branchlet at the edge of the central monsoon low forest*

Figure 15. Cauleryn *[illegible]*

Figure 16. In the foreground, Sporobolus virginicus *saline meadow with a dwarf linear* Aegialitis annulata *mangal (southern tip of the satellite islet).*
To the left, Aegialitis annulata *and to the right* Avicennia marina.

Figure 18. To the right: Rhizophora stylosa *mangal backing the southern satellite islet at extreme low tide. To the left and foreground: mostly bare and sparse seagrass community on wet coralline sand.*

Figure 19. Previous: Bunis argyllioides *climbing over on the seaward side of the central lagoon.*

Figure 30. Lumnitzera racemosa – *Ceriops tagal* mangal at low tide between the southern tidal forest and the inland forest (mean n=3).

Figure 31. Sequential zonation mangal at mid-tide. To the right, the cliff formed by the upper pleistocene limestone. In the background the coastline of Ko Phuket.

Figure 33. Northeastern eroded dead reef flat after clearing of old shingle ridges. *To the right,* Pemphis *tree trunks that used to grow through the levees (August 1990).*

Figure 34. Northeastern eroding shoreline with old Pemphis trunks and new dead mangrove snags. *To the left, on the mainland, dead trees overtopped by the new vegetation (September 1993).*

Figure 24. Lepturus repens - Melanthera biflora *grassland in late spring on sandstone upper beach ridge. To the right,* Scaevola taccada *and* Pemphis acidula *in the background and on the beach crest (1993).*

Plate 36: Upper strand community with Ipomoea pes-caprae *and* Salsola kali *on a fresh sand deposit to the right, a fast growing* Casuarina *thicket, to the left the inner reef flat at low tide (August 1992)*

Figure 37: Ipomoea pes-caprae-sagittata strand community with Salsola kali on the sand terrace to the south of Casuarina equisetifolia thicket (August 1992)

Figure 30 – Unit 1. C. equisetifolia (pine woodland on the eastern sand cay to the right) & Terminalia catappa shrubs on the undercutting. Note the thick C. equisetifolia litter and sparse herb and fern cover.

Figure 31 – Unit 2 Casuarina equisetifolia forest on the central Caribbean reefal accretionary cay.

Part 3
Plant communities

3.1. Methods

Field data were mainly collected in August 1990 and August-September 1992. Additional relevés and transects were made in January-February 1993 and 1995 and some controls in January 1996 and 1997.

The description of the vegetation structure is based on Specht's structural classification (1972) for each layer, modified according to Davie (1987) for mangrove plant communities.

Data were collected from 120 quadrats with plot sizes of between 25 and 500 m^2 depending on the vegetation type. The quadrats were subjectively distributed to represent all the perceptible physiognomic vegetation types. In each quadrat, relevés were made according to the floristic-sociological approach of the Zurich-Montpellier system as reviewed by Bridgewater (1971). According to these principles, all the species of higher plants within the quadrat had to be listed and each of them given a rating based on the scale of cover-abundance of Braun-Blanquet.

Arrangement of the relevés was based on the analysis carried out on the nearby Turtell coral island. The vegetation units were ordered as fixed by the IndVal values (ecological groups) and sets of plots as fixed by cluster analysis (for details cf. De Sloover & Dufrêne 1999).

3.2. The vegetation units

The eighteen accepted vegetation units gave as many structural, physiognomical and ecological units. Their main attributes were expressed in terms of floristic composition, the number of layers and their cover, their mean height as well as the mean frequency and cover of each species.

The vegetation units are each described and commented in detail, with an overview of the habitat(s) they occupy in relation with the geomorphological units in Part 1.

- The reef flat is home to sparse **seagrass communities** whose floristic composition is nearly exclusively made up of marine flowering plants of the Hydrocharitaceae, Posidoniaceae or and Zosteraceae. Moreover, mangroves — *Rhizophora stylosa*, *Avicennia marina* and *Aegialitis annulata* — are able to settle directly on the reef flat either as individuals or sociations.
- Banks of lagoons and moats are exclusively given over to **mangals**. Five mangal communities are recognized depending on their exposure to waves and on the duration of tide flooding.

- Along the windward shore, three successive shingle ridges form the so-called ramparts. Their height above sea level drops, from the inner ridges that are also the oldest to the most recent still partially soaked by the tides. These are devoid of vegetation while the oldest beyond reach of the waves and sprayed only in exceptional storms are stabilized by a **tussock herbfield**. This frequently scrubby low herbfield turns into poor **woodland** species on the lee of the ridges. Moreover, a ***Pemphis* shrub** fringes the very base of the levees where salt water still percolates through coral rubble at high tide.
- Heavily eroded high platforms remain in most cases devoid of soil and the nearby *Pemphis* shrub frequently overhangs their karst-like surface.
- Low benches of conglomerate old platforms flooded by everyday tides are covered with **succulent mats**, more rarely with **saline meadows**.
- The sand cay is almost entirely and densely covered with dynamic connected series starting with freshly deposited sand and **open herbfield** vegetation to old high terraces shielded with **monsoon vine thicket and woodland**. From the pioneering stage to the monsoon woodland, **coastal shrubland** and ***Casuarina* woodland** succeed one another in time and replace one another till the apparent final stage.

3.3. Salt-preferant and salt-tolerant communities

3.3.1. Seagrass communities

From Murdoch Is to Lizard Is, extensive seagrass populations with ground cover categories of over 50% occur apart from the precise area directly surrounding Nymph Is (Lee Long & al. 1989: fig. 6), whereas, according to our observations, sparse seagrass populations are present on Nymph reef flat itself: *Halophila minor* and *Thalassia hemprichii* (fig. 15) are even the species most frequently encountered.

GBR seagrasses are generally intertidal or in shallow subtidal lagoons and pools. Sometimes these lagoons may be well above sea level when the tide is out and marine plants are sustained by water held within the lagoon until the tide rises (Coles & al. 1989). On Nymph Is reef flat, the seagrass communities are exposed to very shallow water particularly during end-summer neap tides.

A single species 'community' of *Halophila minor* is considered a climax under conditions of long exposure that do not seem to be tolerated by other species (Coles & al. 1989).

Sparse but almost uninterrupted seagrass communities were recorded on Nymph Is inner reef flat along the cay and on the western side of the moated sandy pond along the islet (fig. 35 and table 1). *Halophila minor* is the most frequent species all along the westward coast and is at its best in the narrow strip fringing the shore of the sand cay. On the other hand, *Thalassia hemprichii* grows better a bit farther seaward under less shallow waters. Ground cover is particularly low and never exceeds 5%. Our observations are given in table 1: the first three concern the very shallow waters fringing the coast where during neap tides seagrasses like *Cymodocea rotundata*, *Halophila uninervis* but mainly *Halophila minor* are almost stranded. A little further from the coastline in rather deeper waters, *Halophila minor* is accompanied by *Thalassia* and possibly by some algae (table 1, columns 4 to 6).

Table 1. Specific composition and cover in the seagrasses communities on the reef flat of Nymph Is.
Col. 1 to 3: the *Halophila minor* community;
col. 4 to 6: *Halophila minor – Thalassia hemprichii* community.

Column Nr	1	2	3	4	5	6
Ground cover (%)	10	< 5	5	10	< 5	5
Mean height (cm)	4	–	–	–	–	2-4
Surface (sq.m)	0.5	1	1	0.5	4	3
Specific number	2	1	2	2	2	6
Cymodocea rotundata	1	.	.	.	.	.
Halophila minor	1	1	+	1	1	1
Thalassia hemprichii	.	.	.	1	1	+
Halodule uninervis	.	.	1	.	.	1
Halimeda sp.	.	.	.	.	.	1
Padina australis	.	.	.	.	.	+
Boergensenia forbesii	.	.	.	.	.	+

To some extent these impoverished seagrass communities probably correspond to the subtropical assemblages reported from northeast Queensland by Beadle (1981: 613).

3.3.2. Samphires and salty grassland communities

Extensive salt-tolerant herbaceous plant communities occur mainly on conglomerate platforms which form the edging on the southeastern half of the main island as well as on the southern side of the satellite islet; additional patches occur on embankments between the branches of the channel leading to the central lagoon. Their discontinuous ribbon-like mats stretch out under the high tide upper mark.

3.3.2.1. The **samphire* communities** are the most widespread. They are exceptionally submerged but usually partially soaked in the same way as the mangroves are flooded up to the crown. Their poor but generally dense succulent carpet, 5 to 15 cm high, is made up of only three species: *Sarcocornia quinqueflora*, *Sesuvium portulacastrum* and *Suaeda australis*. Between these species, mangrove plantlets apparently without a future are occasionally detected (table 2, columns 8 to 16). The *Sarcocornia quinqueflora* community grows on a thin soil of coral sand and silt and masks the shallow hollows in the platform (fig. 12).

An uncommon variant of that samphire settles on coarser soils above average high tides; it is only found in deep indentations of the continuous scarp of the upper platform or behind the shingle ridges. *Sarcocornia* is absent from that dryer variant which is only

* Frequently used by Australian authors referring to communities of succulent Chenopodiaceae settling in salt pans or saline playas as well as in intertidal zones behind mangroves, the term 'samphire' was originally restricted to a fleshy leaf species from the Apiaceae (*Crithmum maritimum*) and as marsh samphire to the genus *Salicornia*.

Table 2. Specific composition and cover in the salty meadows and samphires communities on Nymph Is.

Col. 1 to 7: *Sporobolus virginicus* salty meadow on southern high platform;
col. 8 to 16: *Sarcocornia quinqueflora* samphire on eastern low platform;
col. 17-18: *Halosarcia indica* samphire on high platform.

Column Nr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
(h) Ground cover (%)	80	75	70	80	90	60	20	100	100	95	100	85	80	55	100	80	45	10
(Sh) Shrub cover (%)	< 5	< 5	< 5	< 5	< 5	.	.	< 5	.	< 1	.	.	.	< 5	< 5	.	.	< 5
Mean height:Ground (cm)	15	10	10	15	15	.	.	7	10	12	10	.	10	5	6	.	.	3
Shrubs (cm)	25	20	30	20	25	.	.	40	.	30	.	.		50	40	.	.	15
Surface (sq.m)	30	35	100	75	50	65	10	25	25	25	25	50	20	40	100	50	20	20
Specific number	6	7	6	6	5	3	3	4	3	3	3	3	3	4	5	3	4	3
Ground cover (herbs)																		
Sporobolus virginicus	**5**	**5**	**5**	**4**	**5**	**3**	2	.	.	.	.	.	.	.	.	.	+	.
Sarcocornia quinqueflora	1	1		2	1	.	2	**3**	**5**	**5**	**5**	**4**	**1**	**+**	**5**	**3**	.	.
Sesuvium portulacastrum	+	+	2	1	+	2	1	3	2	+	2	4	4	3	2	2	2	1
Suaeda australis		1	2	2	.	1	.	3	2	.	2	2	2	1	+	.	3	.
Halosarcia indica															+	+	**1**	**1**
Shrubs cover (shrubs)																		
Osbornia octodonta	1	+	+	+				.	.	.	.	.	.	.	.	.	.	.
Pemphis acidula	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+
Aegialitis annulata		+	+		+			+		+	.	.	.	.	+	.	.	.
Rhizophora stylosa	+	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.
Avicennia marina														+				

moistened during storms or exceptionally high tides (table 2, columns 17-18). As a succulent herb, it has been taken over by *Halosarcia indica* which is rarely found in the widespread samphire dominated by *Sarcocornia* (columns 15-16). The latter community is best developed on Turtell V Is where it occurs behind the grey shingle rampart or even on the upper platform (De Sloover & Dufrêne 1999). *Sporobolus virginicus* occurs rarely among these samphires.

3.3.2.2. The islet's **southern high platform** is subjected to the full force of the ocean splashes. Recurring salt sprays soak the *Sporobolus virginicus* dense mats that make up a closed grassland fringing the *Pemphis* shrub (fig. 16). Besides the salt couch, *Sarcocornia* plays a subdued part as do *Sesuvium* and *Suaeda* (table 2, columns 1 to 7). Scattered mangrove plantlets, in particular *Aegialitis annulata,* foreshadow the mangals that occur in front of these mats in even more exposed situation. The same community also fringes the *Osbornia octodonta* mangal on coral rubbles embankments along the inlet to the central lagoon (fig. 17).

This community is quite different from the monospecific grassland of the *Sporobolus* alliance occurring on saline mud on the landward side of samphire or, in the case of tropics, of mangroves (Beadle 1981).

3.3.3. Mangals

Mangrove communities in the intertidal zone on Nymph occupy either rocky situations such as low conglomerate platforms where they take root in alluvium accumulated in cracks or they are more commonly found on coral sandy deposits mixed with organic matters alongside moats and lagoons shorelines. The depth of regular or exceptional tidal flooding and importance of precipitation are responsible for the selection of mangrove species in the diverse ecotonic habitats. Sea-land zonation of species is however imperceptible and is chiefly expressed as a sequential patchwork related to the physiographic factors. That is why the thirty mangrove species as separated by Bunt & Williams (1980) do not form an invariant zonal sequence as previously stated by Macnae (1966). Nevertheless, the mangrove species are themselves associated with the ecotonic habitats along the tidal range.

Five mangal communities were distinguished here. They differ not only in their specific assemblages but also in the physical conditions experienced such as wave energy, tidal range, frequency and length of flooding, stability and composition of the substratum. This assertion contrasts somewhat with Buckley's conclusion (1982) that advocates concentrating on the ecology of species before identifying 'species associations'.

3.3.3.1. *Rhizophora stylosa* community. This stilt-rooted mangrove frequently forms pure stands as outposts on the reef flat as well as in the middle of the central lagoon. These stands are mainly clones stemming from exceptional settlings (fig. 6, 7 & 18). In the same way larger dense stands fringe the islet's landward coast (table 3, columns 1). These stations are not real plant communities but 'sociations' in the Westhoff & Den Held meaning (1969). Such pure stands of *Rhizophora* occur on the shoreline of moats (Stoddart 1980) and also on lagoons (fig. 8 & 11). They correspond to the *Rhizophoretum stylosae* association found along the Western Australia coast from Exmouth Gulf northward (Bridgewater 1982).

Table 3. Specific composition and cover in the mangal communities on Nymph Is.

Col. 1 to 3: *Rhizophora stylosa* community; col. 4 to 9: *Ceriops tagal* – *Bruguiera exaristata* low closed forest; col. 10 to 13: *Lumnitzera racemosa* mangal; col. 14 to 16: *Osbornia octodonta* mangal; col. 17 to 21: *Avicennia marina* – *Aegialitis annulata* tall open shrub.

Have been extracted from the table: Shrub layer: *Clerodendron inerme* 1 (col. 13), *Flagellaria indica* + (col. 12); Herb & forb layer: *Excoecaria agallocha* 1 (col.12), *Ceriops tagal* + (col.13).

T: trees; Sh: shrubs; l.: layer; (l): climbers.

Column Nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Tree cover (%)	95	100	100	100	85	95	85	85	80	100	70	100	60	.	.	.	.	.	.	.	.
Shrub cover: upper layer (%)	.	.	5	20	25	60	< 5	35	30	30	100	45	15	100	90	.	45	15	5	25	10
lower layer (%)				.	.	.	.	.	.	.	.	.	.	<5	12	40	45	80	15	80	85
Ground cover (%)	.	.	.	.	.	.	.	< 5	.	< 1	.	<5	< 5	.	5	55	.	.	.	<5	.
Mean height: Trees (m)	6	6	6	5.5	5	6	4.5	4.5	2.5	5.5	4	6	6.5	.	.	.	.	.	.	.	.
Sh. upper l. (m)	.	.	3	1.5	1.2	1.5	1	1.5	1	1.5	1.8	1.5	2.8	4.5	3	.	3	2.5	3	4	3
lower l. (m)	.	.	.	.	.	.	.	.	.	.	.	.	.	1.5	1.2	1.5	1	1.2	1.5	0.8	0.85
Herbs (cm)	.	.	.	.	.	.	.	30	.	15	.	15	20	.	20	20	.	.	.	.	.
Surface (sq m)	120	120	100	100	100	100	700	100	100	120	100	100	150	50	100	100	25	100	30	75	80
Specific number	1	3	5	6	9	6	4	7	10	6	3	10	10	5	9	11	5	7	3	5	2
T *Rhizophora stylosa*	**5**	**5**	**5**	4	3	2	1		1	1	.	.	.	.	.	.	.	.	.	.	.
Bruguiera exaristata			1		1	1	3	+	1												
Ceriops tagal		1	1	3		4			+												
Aegialitis annulata					1		3	4													
Avicennia marina					3		2	1	1												
Lumnitzera racemosa				3					3	**5**	**4**	**4**	**4**								
Excoecaria agallocha				1						1	.	3	+								

Sh	*Osbornia octodonta (upper l.)*	.	1	1	.	1	.	.	1	.	.	.	.	.	.	5	5	.	2	.	.	.	.	.	.	.
	(lower l.)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	3	2	1	.	.	.	.	.	.
	Lumnitzera racemosa (upper l.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.
	(lower l.)	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Excoecaria agallocha	.	.	.	.	.	+	.	.	.	.	+	2	1	+	+	.	.	.	+	.	.	.	.	.	.	.
	Ceriops tagal	.	.	.	.	.	3	.	.	.	.	5	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.
	Bruguiera exaristata	.	.	.	1	2	.	.	3	.	.	.	3	1	.	+	.	.	.	.	.	.	.	.	.	.	.
	Aegialitis annulata	.	.	.	2	+	2	.	.	+	2	.	.	.	.	+	1	.	**3**	**5**	**2**	**5**	**5**	.	.	.	.
	Avicennia marina (upper l.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	1	2	1	.	.	.	.
	(lower l.)	.	.	.	.	+	.	.	.	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
(l)	*Cynanchum carnosum*	.	.	+	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	1	.	+	.	.	.	.	.
	Rhizophora stylosa (upper l.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.
	(lower l.)	.	.	.	.	2	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.
	Pemphis acidula (upper l.)	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
	Sonneratia alba	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
	Batis argillicola	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.
h	*Sporobolus virginicus*	.	.	.	.	.	.	.	.	.	+	.	1	+	.	2	3	.	.	+	.	.	.	.	.	.	.
	Suaeda australis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.
	Sarcocornia quinqueflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.
	Sesuvium portulacastrum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.
	Aegialitis annulata (pl.)	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	.
	Osbornia octodonta (pl.)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.

Communities towered by stilt-rooted mangroves are always poorly structured with only a few other species like *Ceriops tagal* or *Osbornia octodonta* (table 3, columns 2-3).

3.3.3.2. *Ceriops-Bruguiera* low closed forest (table 3, columns 4 to 9). Genuine mangrove communities line the central lagoon banks (fig. 10). Stilt-rooted mangrove is still frequent and in some cases even codominant (columns 4-5). However, other mangrove species like *Ceriops tagal* (columns 4 and 6), *Bruguiera exaristata* (column 7) or *Avicennia marina* (column 3) and *Aegialitis annulata* (columns 7 and 8) play a major role in this mixed mangal. Trees grow to an average of only about 5 m (4.5 to 6) and the understorey whose cover averages 30% does not exceed 1.5 m. *Sonneratia alba* and *Batis argillicola* (fig. 19) occur in that undergrowth as well as *Pemphis acidula*. *Xylocarpus moluccensis* is surprisingly scattered and *Heritiera littoralis* totally lacking even though its seeds are regularly found on Nymph beaches.

The characteristic feature of that coral island mangal is its scaled-down height: even under the most sheltered conditions, the tree crown barely reaches a third of its normal height in mainland estuary mangals. Its like could be found in the *Bruguiera* forest in Papua New Guinea as depicted by Percival & Womersley (1975). The Pilbara tidal creek systems (Bridgewater 1982) display a mid-mangal *Ceriopo-Bruguieretum* association which could be the equivalent of the *Ceriops-Bruguiera* closed forest.

The nearest island to support the same community is Turtell V (De Sloover & Dufrêne 1999). It should be noted that *B. gymnorhiza* merely substitutes there for *B. exaristata*. As already mentioned, Stoddart & Fosberg (1991) did not identify a *Bruguiera* woodland on the coral islands of the northern GBR while Stoddart (1980) had previously mentioned a mangal mature woodland including *Ceriops*, *Bruguiera* and *Xylocarpus* on more protected substrates. In addition, Hopley (1982) noticed a community whose dominant species pertained to the genera *Bruguiera* and *Ceriops*. The *Ceriops-Bruguiera* closed forest thus seems to be a community which has definitely spread on the northern cays of the GBR.

3.3.3.3. *Lumnitzera* mangal (table 3, columns 10 to 13). Although occurring as a tree in the former closed forest, *Lumnitzera racemosa* is not very frequent there. However, in isolated stands such as the swamp woodland backing up the relictual moat cut off from direct tidal influence by the huge northern mixed shingles and sand rampart, *Lumnitzera* indeed dominates the mangal (table 3, columns 11 to 13, fig. 20). The same conditions also prevail when the mangal is set apart from the ocean by a sand bank (column 10).

In all four stands salt water from each tide slowly seeps through the levee and wets the soil but without any flooding. *Excoecaria agallocha* clearly prefers that entrenched situation and may be found in the understorey in the company of *Ceriops*, *Bruguiera* and *Aegialitis*.

3.3.3.4. *Osbornia* mangal (table 3, columns 14 to 16). As opposed to *Lumnitzera*, the ecological preferences of *Osbornia octodonta* communities seem confined to well-drained soils like the coral sandy embankments in the outlet of the main lagoon (fig. 10 & 17). They form low closed shrubland up to 4 m high (table 3, columns 14-15), in these stands regularly flooded by tidal flows. When the cover opens out, herbs and samphires, for instance *Sporobolus* and/or *Sarcocornia*, encroach on the existing vegetation. *Batis argillicola* seems to find there its niche on Nymph Is (table 3, columns 15-16).

3.3.3.5. *Avicennia-Aegialitis* tall open shrubland. On the southern shore of Nymph Is, small patches of mangroves battle with winds and waves particularly around its satellite islet (table 3; fig. 16 & 21). *Avicennia marina* and mainly *Aegialitis annulata* form the small group making up the tiny association often reduced to a 'sociation'. Only a few species make up the set and, among them, the presence of *Sonneratia alba* must be stressed. That pioneering mangrove does not constitute a community on Nymph where its establishment is prevented by strong wave action. *Aegialitis* forms buttressed shrubs in the *Avicennia-Aegialitis* community that cling to the reef flat or often to the outer edge of old eroded platforms. In these situations, the vegetation upper layer scarcely reaches a mean height of 2.5 to 3 m and a mean cover of some 20%. It can be placed in Bridgewater's *Aegialithion* alliance and is the equivalent of Pilbara's *Aegialitetum annulatae* association (Bridgewater 1982). Chapman (1975) placed it in the *Avicennion* alliance.

3.3.3.6. *Pemphis* tall closed shrubland. Even if specialists position it among mangroves (Percival & al. 1975, Tomlinson 1986; Wightman 1989), *Pemphis acidula* shows quite different requirements in comparison to true mangroves. We did not record its presence on Turtell V Is (De Sloover & Dufrêne 1999). On Nymph Is however, we noted a *Pemphis* grove thriving in isolation on the reef flat flooded at each tide. In fact, that grove was a residual one stemming from the thicket growing on an old shingle rampart that had been completely dismantled to the level of the reef flat on which it was originally built (fig. 22 & 23). The grove was still standing up on end: it was firmly rooted in the underlying reef flat because its root system had forced its way through the levee to get at the salt water. So we shifted the community to the mangal group, although it could also be placed among the plant communities on shingle ridges.

Found throughout the Indo-Pacific region, the *Pemphis* community shows a simple structure in that the plant forms by itself the whole shrub canopy providing nearly full cover (90 to 100%). The ground cover remains very weak with only a few herbs namely *Sesuvium*, in the understorey. The height of the thicket does not exceed 3 m and this includes several undemanding mangrove species like *Excoecaria agallocha* or *Osbornia octodonta* (table 4, columns 3 to 6). Vines like *Cayratia trifolia* or *Canavalia rosea* are frequent.

The *Pemphis* evergreen shrub achieves its optimal development on the lower slopes of old shingle ramparts; it forms a fringe running from the northern tip of the island along the whole length of the eastern shore as shown on the map (fig. 35). Additional stands encircle small recently ponded mangroves along the western shore and also crown high platforms (fig. 7 & 8) on the satellite islet.

3.4. Plant communities on shingle ridges: from vine herbfield to scrubby grassland

On the eastern shore, the harsh environment made up by the high coarse coral levees become very slowly and sparsely overgrown. Patches of shrubs progressively succeed to the open initial grassland and build up the following community.

***Lepturus repens-Myoporum acuminatum* community**

Grasslands are a common feature of most coral islands. On coral cays of the GBR northern section like the nearby Eagle Is or Turtell V Is, grasslands occupy the sandy cays and

Table 4. Specific composition and cover in the *Pemphis acidula* tall closed shrubland.
Sh: Shrubs, h: Herbs & forbs, pl.: plantlets, l: climbers.

Column Nr	1	2	3	4	5	6
Sh – Shrub cover (%)	100	95	100	90	100	100
h – Ground cover (%)	< 1	< 1	< 1	20	< 1	.
Mean height: Shrubs (m)	2	2	2	2.5	3	3
Herbs (cm)	2	.	6	8	10	.
Surface (sq.m.)	50	50	75	100	250	80
Specific number	4	4	3	5	8	2
Sh *Pemphis acidula*	**5**	**5**	**5**	**4**	**5**	**5**
(l) Canavalia rosea	1	2	.	.	.	.
(l) Cayratia trifolia	+	.	.	.	.	.
Excoecaria agallocha	.	.	+	.	+	.
Osbornia octodonta	.	.	.	2	+	.
Lumnitzera racemosa	.	.	.	+	.	.
Ceriops tagal	.	.	.	.	+	.
Rhizophora stylosa	.	.	.	.	.	+
Aegialitis annulata	.	.	.	+	.	.
Guettarda speciosa	.	1	.	.	.	.
Myoporum acuminatum	.	.	.	.	+	.
h *Sesuvium portulacastrum*	+	.	+	1	.	.
Pemphis acidula (pl.)	.	.	.	.	+	.
Achyrantes aspera	.	+	.	.	.	.
Lepturus repens	.	.	.	.	1	.
Commelina undulata	.	.	.	.	+	.

are constrained by ground-nesting seabirds that deeply affect vegetation structure and composition (De Sloover & Liégeois 1997). On Nymph Is the extensive grassland occupies a quite different habitat. It covers the huge shingle ramparts built on the eastern shore where the soil grows mainly on coarse coral debris piled up with some coral sand. That harsh substratum combined with the windswept orientation creates an unusual setting that controls the vegetation. This grassland is for its most part concealed behind the fringe of *Pemphis* scrub bordering the lower slope of the eastern ramparts and covers the shingle levees laid out in successive tiers.

The close tussock grassland is constantly dominated by *Lepturus repens*. Its phenology is contrasted between the dry (fig. 24) and rainy seasons (fig. 25). The grass is found consistently with forbs like *Canavalia rosea* and *Boerhavia albiflora* and to some extent *Euphorbia tannensis* and *Cleome viscosa* (table 5). Creeping vines like *Cassytha pubescens*, *Ipomoea macrantha* and *Passiflora foetida* are a striking feature of that grassland. This type of *Lepturus* grassland corresponds both to the herb flat description made by Heatwole (1976) and to Fosberg's (1976) *Lepturus* meadow. Repartition of *Melanthera*

Table 5. Specific composition and cover in the shingle ridges *Lepturus repens* grassland.
Col. 1 to 5: the typical grassland with *Melanthera biflora*; col. 6 to 12: the scrubby grassland (*Lepturus – Myoporum* community).
Have been extracted from the table: *Scaevola sericea* 2 (col.3), *Pemphis acidula* 1 (col. 6).
h: herbs; Sh: shrubs; l: climbers.

	Column Nr	1	2	3	4	5	6	7	8	9	10	11	12
	Total cover (%)	95	95	70	90	95	95	95	95	100	100	95	85
	(Sh) Shrubs cover (%)	< 5	< 5	20	< 5	15	10	20	40	40	40	50	60
	(h) Ground cover (%)	95	95	70	90	80	85	80	75	70	80	50	80
	Mean height: Shrubs (m)	–	0.6	0.7	0.8	2	0.8	1.5	1.8	1	1	1	1.7
	Herbs (cm)	20	20	15	25	30	30	20	30	40	40	30	30
	Surface (sq.m)	100	100	100	100	100	100	300	200	200	200	250	100
	Specific number	7	8	9	15	13	10	15	14	11	16	14	14
h	*Lepturus repens*	5	5	3	5	4	4	3	4	4	5	3	5
	Canavalia rosea	1	+	1	1	3	1	2	2	3	1	2	+
	Boerhavia albiflora	.	+	.	+	1	1	2	+	1	+	1	+
	Euphorbia tannensis	.	.	.	+	+	.	+	+	.	.	.	+
	Cleome viscosa	.	.	.	1	1	.	+	+	.	.	.	+
	Melanthera biflora	3	3	3	2	1	.	.	.	.	.	.	+
	Ipomoea pes-caprae	+	.	.	+	.	.	.	.	.	.	.	.
	Sporobolus virginicus	.	+	.	+	.	.	.	.	.	.	.	.
	Cassytha pubescens	1	2	+	1	1	2	+	2	1	+	.	+
	Ipomoea macrantha	+	.	1	.	1	.	3	1	2	+	2	.
	Passiflora foetida	+	+	.	+	.	1	2	2	.	+	2	.
	Achyrantes aspera	.	.	.	.	+	.	.	+	.	+	+	+
	Commelina undulata	.	.	+	+	+	.	1	.	.	.	.	.
	Bulbostylis barbata	.	.	+	+	.	.	.	.	.	.	.	+
	Cayratia trifolia	.	.	.	.	+	+	+	.	.	.	.	.
Sh	*Myoporum acuminatum*	.	+	2	+	2	.	.	3	1	.	.	3
	Capparis lucida	.	.	.	+	.		1	1	1	1	1	1
	Vitex trifolia							2	.	.	2	2	.
	(l) Canavalia rosea	.	.	.	.	1	+	2	+	2	1	1	.
	(l) Passiflora foetida						+	1		1	+	1	
	(l) Cayratia trifolia							+		+	+	+	
	Premna serratifolia	.	.	.	+	.				3	.		1
	Ficus opposita										2	2	
	Terminalia muellen								1				2
	Mimusops elengi						1						+
	(l) Ipomaea macrantha	.	.	.	.	.	.	.	1	.	+	.	
	(l) Cassytha pubescens	.	.	.	.	.	.	.	.	.	1	1	
	Abutilon asiaticum	.	.	.	.	.	.	.	.	.	+	+	

biflora in the grassland seems confined to the most southeastern exposed ridge (fig. 24) and the concomitant presence of *Ipomoea pes-caprae* and *Sporobolus* points to distinctive soil conditions stemming from the more sustained salt sprays on the southern end of the levee (table 5, columns 1 to 5). In spite of quite different soil conditions, the present *Lepturus* grassland community matches that of Turtell V Is where the substratum is pure coralline sand and despite the marked impact of birds (De Sloover & Dufrêne 1999).

The species most prominent in the shrub community are *Capparis lucida*, *Vitex trifolia* and *Premna serratifolia*. Shrub cover spreads from under 5% (table 5, columns 1 to 3) to over 50 % (columns 11-12) forming a kind of dwarf savanna where the height of the scrubby layer does not exceed 1.5 to 2 m. Tree growth seems inhibited on this windward slope; even scraggy trees are infrequent. As opposed to the shrubby grassland on the wind side embankment, stunted woodland appears on the opposite leeward slope facing the main lagoon (fig. 35).

3.5. Plant communities and soils on the sand cay

As described for most Pacific sand cays, pioneering species mainly carried by the sea settle on freshly deposited coral sand bank. These deposits are found on sheltered shores where sea currents overloaded with fine detritic materials are weak. Hence heaping up occurs and when standing out, the piled up coral sand adds to the shoreline that grows at the expense of the reef or of the other shores of the island itself. This process is still active on Nymph Is but only on a cramped bay of the southwestern strand line. Other processes however may contribute to the expansion of a cay. In this way, sand drifted by wind may pile up to build higher terraces but nowadays this standard way is exceedingly limited on Nymph Is. Moreover, geological studies reveal that fresh material does not seem to have been added to Nymph reef and newly built shorelines are the only results of the reshaping of old material. High sand terraces built up at the time of higher sea levels are now for the most part wrapped under woodland or forest and are almost stable.

3.5.1. Pioneering upper beach herbfield

The very limited expanding shoreline explains the small number of current relevés. Nevertheless, restricted upper beach herbfield communities are those of usual strand vegetation as described by Heatwole (1976). On Nymph Is, the pioneering stage (table 6, columns 1 to 3, fig. 3, 26 and 27) is comparatively and specifically poor and was from the beginning settled by *Casuarina* saplings. A few littoral shrubs like *Suriana maritima* or *Colubrina asiatica* point to the transient stage of that pioneering herbfield (table 6, columns 4 and 5). Today, a dense thicket made exclusively of *Casuarina* forms the background of the community, contrasting with the *Aglaia* thicket, and shows the next progression stage.

3.5.2. Littoral scrub

Scrub species like *Colubrina asiatica* or *Suriana maritima* are settling among the pioneering species of the foredune herbfield (table 6, column 5). They are the first stages of the next vegetation unit, the littoral scrub. And yet, on Nymph Is there are no signs that the littoral scrub heralded by these latest vegetation samples is spreading: only a few incomplete traces of that community are detected on the littoral edge of the *Casuarina* woodland.

Table 6. The upperbeach herbfield (*Ipomœa pes-caprae* community).
h: herbs & forbs; Sh: shrubs.

	Column Nr	1	2	3	4	5
	(Sh) Shrub cover (%)	<1	.	<5	8	5
	(h) Ground cover (%)	8	10	15	15	60
	Mean height: Shrubs (m)	0.8	.	1.5	0.8	0.8
	Herbs (cm)	10	3	20	35	10
	Surface (sq.m)	50	40	75	40	80
	Specific number	3	4	8	7	9
h	*Ipomoea pes-caprae*	2	1	1	.	.
	Canavalia rosea	.	2	2	.	.
	Euphorbia atoto	.	.	1	.	.
	Salsola kali	+	.	+°	2	1
	Lepturus repens	.	+	+	+	1
	Sporobolus virginicus	.	.	1	+	2
	Sesuvium portulacastrum	.	.	.	+	4
	Euphorbia tannensis	.	.	+	.	.
	Cassytha pubescens	.	.	.	.	.
Sh	*Casuarina equisetifolia*	+	1	+	1	+
	Suriana maritima	.	.	.	+	1
	Argusia argentea	.	.	.	1	.
	Colubrina asiatica	.	.	.	.	1
	Myoporum acuminatum	.	.	.	.	1
	Sophora tomentosa	.	.	.	.	+

3.5.3. *Sorghum* grassland

The only grassland to colonize the sand cay is of rather uncommon occurrence. It settles clearings of the *Casuarina* woodland or of the *Aglaia* shrubland. The only spot to have been reported on the map constitutes the largest observed colony made up of this recent invader, which dominates the community where grasses are in the majority with only a few weedy forbs (table 7). The usual woody invaders are those of the littoral scrub like *Colubrina asiatica* or shrubs or trees of the *Aglaia* shrubland, *Drypetes lasiogyna* or *Terminalia muelleri*, for example.

3.5.4. *Casuarina* woodland

In our opinion, the Nymph Is *Casuarina* woodland stands out not only as the finest in the GBR's northern section but also as a paradigm to understand the vegetation dynamic on coral islands. This evergreen narrow sclerophyll woodland embraces the whole western shore in the shape of a boomerang of which the maximal width intersects the island north-western corner exactly level with a small ponded lagoon (fig. 35 & 37). Its western edge

Table 7. Specific composition and cover in the *Sorghum plumosum* grassland.
Have been extracted from the table: herbs & forbs: col. 1: *Abrus precatorius* +, *Cyperus pedunculatus* +, *Tacca leontopetaloides* +, *Xenostegia tridentata* + .
col. 2: *Commelina undulata* +, *Passiflora foetida* + .
h: herbs & forbs; Sh: shrubs; j, juvenile.

Column Nr		1	2
(h) Ground cover (%)		55	80
(Sh) Shrub cover (%)		–	5
Mean height: herbs (cm)		25	80
shrubs (m)		–	4
Surface (sq.m)		30	400
Specific number		13	13
h	*Sorghum plumosum*	3	4
	Bulbostylis barbata	+	1
	Cassytha pubescens	+	1
	Lepturus repens	.	2
	Cyperus tetracarpus	2	.
	Boerhavia albiflora	+	.
	Canavalia rosea	.	1
	Cleome viscosa	1	.
	Portulaca australis	1	.
	Evolvulus alsinoides	+	.
Sh	*Drypetes lasiogyna (j.)*	+	1
	Myoporum acuminatum	+	+
	Premna serratifolia	.	1
	Terminalia muelleri	.	1
	Colubrina asiatica	.	+
	Eugenia reinwardtiana	.	+

skims the high water line and from there stretches towards the island centre (fig. 3; table 8). Along that line, the soil level rises by degrees of which at least two levels, those between 2.0 and 2.60 m a.s.l. (above sea level), can be easily spotted.

3.5.4.1. Soils and heterogeneousness of the woodland. Under *Casuarina*, woodland incipient soil may be interpreted as a progressive step from freshly deposited coral sand on the front of the cay to more developed soils behind former shorelines. As time goes by and at the same time as the deposit of new sand terraces, the *Casuarina* saplings settle on the latest shoreline added to previous ones by successive but erratic wave impact. Recent *Casuarina* groves like those already described on the southern part of the cay (cf. Pioneering upper beach herbfield) are thus added and become uniform woodland. It is a fact that on Nymph Is such woodland comprises a discontinuous series of decreasing ages of *Casuarina* trees thriving on sand terraces that were built up successively. Four terraces can be detected on the present sand cay: they are covered with ill-assorted woodland whose

Table 8. Specific composition and cover in the *Casuarina equisetifolia* open thicket on shingle ridges.

Have been extracted from the table: *Pemphis acidula* +, *Rhynchosia minima* +, *Commelina undulata* + (col. 3).

h: herbs & forbs; Sh: shrubs.

Column Nr		1	2	3	4
(Sh) Shrub cover (%)		5	8	20	25
(h) Ground cover (%)		60	15	80	<1
Mean height: Shrubs (m)		0.8	0.8	5	1
Herbs (cm)		10	35	25	10
Surface (sq.m.)		80	40	80	200
Specific number		9	7	13	13
Sh	*Casuarina equisetifolia*	+	1	2	2
	Myoporum acuminatum	1	.	+	1
	Argusia argentea	.	1	.	.
	Suriana maritima	1	+	.	.
	Colubrina asiatica	1	.	.	.
	Sophora tomentosa	+	.	.	.
	Cordia subcordata	.	.	.	2
	Carissa laxiflora	.	.	.	+
	Capparis lucida	.	.	.	+
	Diospyros compacta	.	.	.	+
	Cayratia trifolia	.	.	.	+
	(l) Canavalia rosea	.	.	.	1
	Terminalia muelleri	.	.	.	1
h	*Lepturus repens*	1	+	2	.
	Sporobolus virginicus	2	+	.	
	Salsola kali	1	2	.	.
	Sesuvium portulacastrum	4	+	.	.
	Ipomoea macrantha	.	.	2	+
	Canavalia rosea		.	4	+
	Achyranthes aspera			+	+
	Passiflora foetida			+	.
	Boerhavia albiflora			.	+
	Cassytha pubescens			1	
	Cayratia trifolia			+	
	Cleome viscosa			+	

characteristics are reflected in the density, structure, composition of the vegetation and in the old habit of the successive but irregular influx of *Casuarina* trees. The soil sampling taken when analysing the vegetation within the vegetation plots (table 9) reinforces the interpretation already put forward i.e. a succession of populations from the frontline dense woodland (columns 1 to 9) to the rear sparser trees populations (columns 16 to 21). For convincing arguments see 3.5.6, Sand cay soils.

Table 9. Specific composition and cover in the *Casuarina equisetifolia* woodland.

Col. 1 to 9: Mature stage on terrace I; col. 10 to 22: Mature and senescent stages on terrace II and III.

Have been extracted from the table: *Salsola kali* + (col. 3), *Tacca leontopetaloides* +, *Capparis sepiaria* + (col. 6), *Cocos nucifera* + (col. 8), *Hova oligotricha* + (col. 14), *Breynia oblongifolia* + (col. 17), *Flagellaria indica* +, *Melanthera biflora* + (col. 18), *Schefflera actinophylla* + (col. 21).

T: trees; Sh: shrub; (l): climber; h: herbs & forbs.

Column Nr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
(T) Tree cover (%)	80	60	95	80	85	80	85	85	35	15	30	30	15	20	55	60	60	40	20	10	<5	.
(Sh) Shrub cover (%)	15	20	20	5	30	20	25	10	25	7.5	35	20	20	55	60	20	15	45	55	55	35	80
(h) Ground cover (%)	80	40	100	55	95	70	50	40	20	30	40	75	25	15	15	30	30	30	35	25	15	10
Mean height: Trees (m)	5 5	7	7 5	7	6 5	11	6	7	6	6.5	7	10	7	11	9	9.5	11	10	11	11	8	.
Shrubs (m)	1	1 25	1 5	1 5	3 5	1	1 8	2.5	0.8	2.25	3	2.5	3.25	2.5	3	2.75	3	4	3	3	3.25	3
Herbs (cm)	20	30	30	30	25	15	20	15	60	25	25	25	25	20	25	25	25	25	25	25	20	20
Surface (sq m)	100	80	100	250	120	60	60	120	100	400	600	700	1000	700	450	450	500	500	700	500	700	250
Specific number	11	11	6	10	12	12	12	14	14	12	17	14	18	25	17	16	15	18	19	24	23	18
T *Casuarina equisetifolia*	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	3	2	3	3	2	2	4	4	4	3	2	2	+	.
Sh *Suriana maritima*	2	2	2	.	2	.	2	2	+	.	.	2	.	.	.	.	.	.	.	.	.	.
Argusia argentea	+	1	.	.	.	.	.	1	.	1	+	+	.	.	.	.	.	.	.	.	.	.
Scaevola sericea	.	.	.	+	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(l) *Canavalia rosea*	+	+	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Vitex trifolia	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Premna serratifolia	+	+	1	1	1	2	.	+	.	1	2	2	1	1	2	+	2	2	+	+	2	.
Mycaporum acuminatum	1	1	.	.	.	.	1	.	1	+	.	.	+	.	+	2	.	.	.	.	+	.
Colubrina asiatica	.	.	+	.	.	.	1	.	2	1	+	.	+	.	.	1	.	.	.	.	+	.
Cordia subcordata	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sarcostemma australe	1	1	.	.	2	.	.	+	1	.	.	.	.	+	+	.	.	.	+	+	.	.
Pemphis acidula	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.
Thespesia populnea	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ipomaea macrantha	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hibiscus tiliaceus	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(l) *Cayratia trifolia*	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
Guettarda speciosa	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.

	Terminalia muelleri				2	+	+	1		1	2	1	1	2	3	2	2	2	1	+	1	1
	Drypetes lasiogyna					1		+			+	1	+	3	+	+	1	+	2	2	+	3
	Mimusops elengi							+			1	1		1	+	1	2	1	1	2	1	2
	Micromelum minutum											+	+	1	+	+	+	+	1	+	1	+
(I)	*Cassytha pubescens*									+			+	+	+	+	+	+	.	+	+	1
	Planchonella obovata					+					.	1	2	2	.	.	+	+	2	2	2	.
	Capparis lucida							+			+			+	.	1	+	.	+	.	+	+
	Eugenia reinwardtiana										.	.	+	+	+	.	+	.	+	2	.	2
	Ficus opposita			+							.	.	.	+	.	.	.	1	.	+	.	+
(I)	*Abrus precatorius*		+								.	.	.	+	+	+	.	.	.	+	+	.
	Diospyros compacta						+				.	.	.	.	.	.	.	+	1	2	.	2
	Manilkara kauki										.	.	.	.	1	+	.	.	.	+	1	1
	Cassine melanocarpa						+				.	.	.	+	.	.	.	.	.	1	.	.
	Chionanthus ramiflora										.	.	.	1	.	.	+	.	+	1	+	.
	Aglaia elaeagnoidea										.	.	.	2	.	.	.	.	1	1	.	1
(I)	*Opilia amentacea*										.	.	.	1	.	.	.	.	1	+	.	+
	Vavaea amicorum													.		+		+	+	+	.	.
	Carissa laxiflora										.	.	.	+	.	.	.	+	.	.	.	+
	Canthium coprosmoides										.	.	.	1	.	.	.	.	.	.	+	.
	Celtis philippensis										.	.	.	.	.	.	.	.	.	+	+	.
	Psychotria nesophila										.	.	.	+	.	.	.	.	.	.	.	.
	Scolopia braunii										.	.	.	.	.	.	.	.	1	.	.	.
h	*Lepturus repens*	5	3	4	3	5	4	3	2	2	3	3	4	2	2	2	3	3	3	2	1	2	2
	Canavalia rosea		1	.	1	.	1	+	+	1	1	+	+	1	.	+	+	.	.	.	.	.	.
	Euphorbia tannensis	+			1	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.
	Tribulus cistoides				+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.
	Thuarea involuta	+	1	4	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Ipomoea pes-caprae		+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Euphorbia atoto		+											.									
	Vitex ovata							+	.	.	.	.	.		.	.	.	.	.	.	.	.	.
	plantlets (div. sp.)									.	.	.	+		.	.	.	.	+	2	2	.	.
	Cleome viscosa	+			+		1			2	1	2	1	1	1	1	1	+	1	+	+	1	1
	Boerhavia albiflora						+			+	.	.	.	+	+	+	+	+	.	.	+	+	.
	Cassytha pubescens									+	.	.	.	+	1	.	.	.	.	+	+	.	+
	Bulbostylis barbata									.	.	+	.	+	+	+	.	.	1	.	+	1	1
	Sporobolus virginicus							1	2	.	.	.	.	+	.	.	.	.	.	.	.	.	1
	Amaranthus interruptus									+°	.	.	.	1	.	.	.	.	.	.	+	.	

3.5.4.2. A sea traveller tells the woodland story. Samaras of *Casuarina equisetifolia* are dispersed by wind but most of the dispersed nuts settle on the sea and travel with ocean currents (Ridley 1930). They eventually land on a shore or above it and germinate. A new line of *Casuarina* saplings or young trees thus indicates the moment in time when seeds carried by tides were deposited and germinated on the shoreline. This is a well-known ecological feature of the subsp. *incana* which is a sea traveller ruling the *Casuarina* woodland settlement on coral cays.

On Nymph Is, a few isolated old *Casuarina* trees are found farther inland where their crowns tower over the *Manilkara* forest (fig. 31). They could be the sign of old shorelines in the same way as the successive settlings along the gradient from the present high-tide mark to the inner most inland specimens. Ridley (1990) reported the same phenomenon on the Borneo coast where *C. equisetifolia* forms a line at a considerable distance from the beach. He concluded that the sea had in fact receded since the time the trees were established and were then left inland. This can explain the settling of the *Casuarina* woodland as structured on Nymph Is.

3.5.4.3. Vegetation features. After settlement, growth is fast and dense populated rows rule out any undergrowth as in the grove at the rear of the only new beach building at the southern end of the sand cay (cf. 3.5.1, Pioneering upper beach herbfield).

Sparser young communities are however encountered on the northern shingle levees where sand makes up an appreciable part of the solum (table 8, fig. 5). Typical species of the littoral scrub are often dominant in the understorey next to characteristic although rarer species on Nymph Is, for instance *Sophora tomentosa* and *Carissa laxiflora*. This feature emphasizes the close relationships between incipient *Casuarina* woodland and the littoral scrub. *Casuarina* woodland is, as it was, a singular case of littoral scrub evolution: in its earliest stages, *Casuarina* is one among other shrubs associated with the upper beach community but, owing to its fast growth, it may later overcome or eliminate all the other shrubs to establish a semi-permanent community.

Twenty-two relevés were made in the *Casuarina* woodland on the sand cay and they are grouped in table 9 in three comprehensive groups, based on the results of a DCA (Detrended Correspondence Analysis).

In the first group of relevés (table 9, columns 1 to 9) tree crowns often unfurl to a height of over 10 m (8.5 m as a mean) and provide up to 85% cover. The undergrowth is scattered and covers less than 20 % (fig. 28 & 29). Significant littoral scrub species such as *Suriana maritima* or *Argusia argentea* still grow in the understorey whereas they will disappear under the pressure of more 'inland' shrubs or small trees. The same decrease is true for herbs and forbs like *Thuarea involuta* and *Euphorbia tannensis* whose ground cover exceeds 65% under typical *Casuarina* woodland (table 9, columns 1 to 9) and declines to under 25% where dense thicket forms the undergrowth (columns 16 to 22). However, some of these littoral shrubs, like *Premna serratifolia*, and herbs such as *Lepturus repens*, are hanging on, in spite of the competition from more recent invaders.

The number of species, close to 11 in the typical *Casuarina* woodland (columns 1 to 9), rises to 19 when the tree cover drops to about 30% (columns 10 to 21). Woodland invaders are typical shrubs or trees from the *Manilkara* closed forest that will outclass the declining woodland: the most aggressive among them — *Terminalia muelleri* (fig. 30),

Drypetes lasiogyna and *Mimusops elengi* – are already in the first stages of this take-over. With them come other forest trees or shrubs like *Planchonella obovata* or *Eugenia reinwardtiana* (table 9, columns 10 to 22).

When the *Casuarina* woodland goes into decline, tree cover drops to some 15% but then other broadleaf species like *Chionanthus ramiflora, Aglaia elaeagnoidea* and *Vavaea amicorum* step in, providing their own cover (table 9, columns 16 to 22), so cover rises to around 50%.

3.5.4.4. Growth and thickness increase. Given the hardness of the wood, it was impossible to evaluate the individual age of *Casuarina* trees by means of a Priestley auger. We therefore replaced the usual evaluation procedure based on growth rings with other parameters that could be combined to determine the approximate tree age. *Casuarina* throws out considerable buttresses, originating in the most superficial roots and serving as anchorage roots (Fosberg 1976). These get thicker and stretch far from the trunk giving the base of the tree a multi-star outline in section (fig. 31). A few of the oldest buttresses even form real planks.

Three parameters were taken into account: (1) tree base development (i.e. the outline measured at the very base of the trunk, outline that replicates the star-like contour drawn by the buttresses), (2) trunk circumference measured above the buttresses and (3) buttresses height. The results of these measurements are summarized in table 10.

Buttresses length increases significantly from Terrace I to Terrace III tree populations and even more for the few which thrive further inland, presumably as relicts in the midst of the broadleaf forest (table 10). The height of the buttresses leaning on the trunk and the trunk circumference also increase significantly from Terrace I to Terrace IV. These results certainly confirm the linkage between the presumed age of *Casuarina* trees and their present distance from the shoreline.

Table 10. Growth parameters of *Casuarina* trunks on the four successive terraces.
Data are shown with means ± standard errors; number of samples = 6. Results from one-way Anova (F, p), different letters indicate significant differences ($p < 0.005$).

Growth parameters	Terrace I	Terrace II	Terrace III	Terrace IV	F, p
Perimeter at basis (m)	1.9 ± 0.2 ^{c}	3.0 ± 0.2 ^{c}	9.7 ± 0.8 ^{b}	18.1 ± 1.3 ^{a}	93.79 < 0.0001
Trunk circumference (m)	1.5 ± 0.1 ^{b}	1.6 ± 0.2 ^{b}	2.1 ± 0.1 ^{a}	2.3 ± 0.2 ^{a}	6.85 0.0023
Buttresses height (cm)	4.5 ± 2.9 ^{c}	12.0 ± 1.6 ^{c}	25.0 ± 2.4 ^{b}	40.3 ± 3.3 ^{a}	35.38 <0.0001

In table 9 vegetation plots on Terrace I are combined in columns 1 to 9, those on Terrace II in columns 10 to 15, those on Terrace III in columns 16 to 23; dashed lines thus divide the table into the three groups of woodland plots set up on the three presumed Terraces. Terrace IV represents the upper terrace covered by the *Mamikara* forest which in fact surrounds only a few clumps of apparently the oldest *Casuarina* trees on the island.

3.5.5. Central broadleaf forest and shrubland

Behind the *Casuarina* woodland on the top of the low dome formed by the cay as well as on its sides turned towards the central lagoon, the evergreen broadleaf forest and associated shrubland cover roughly half the surface of the cay. This evergreen vine forest looks at its best on the gentle eastern and northern slopes and is replaced on the windswept top by a patchwork formed by a shrubby community.

3.5.5.1. *Manilkara* low closed forest. The *Manilkara* closed forest was first described on nearby Turtell V Is (De Sloover & Dufrêne 1999, De Sloover 2003). On Nymph Is, *Manilkara kauki* (fig. 32) is not the only dominant tree: in half of the vegetation plots studied, other broadleaf species like *Aglaia elaeagnoidea*, *Drypetes lasiogyna* and *Terminalia muelleri* escort the emblem tree to establish a mixed broadleaf forest (table 11, columns 1 to 8). Tree height is unexceptional as it does not exceed 8 m (with a mean of 6 m). Tree cover can reach 90% but the mean is lower, around 75% (fig. 32 & 33). In that tree layer, the presence of *Vavaea amicorum* drew our attention as did the liana-like *Opilia amentacea* and unusual climbers such as *Capparis sepiaria* and even *Sarcostemma australe*.

The relatively dense shrubby understorey reaches a mean of some 70% and is particularly diversified with more than fifteen species among which *Cassine melanocarpa*, *Glycosmis pentaphylla*, *Diospyros maritima*, *Polyalthia nitidissima* and *Scolopia braunii* are noteworthy. The most prominent climber is without doubt *Hoya oligotricha* which often literally entangles the undergrowth and restrains any move (fig. 34)

Figure 32. In the middle of the central shrubland surrounded with the forest. Nymph Is, Australia.

Forbs of the herb layer exclusively include shrubs and juvenile trees; their mean cover reaches only 30 %.

In these coastal monsoon vine forests and shrublands, seasonally dry substrates possibly lead to the retention of foliage in a wilted state exhibited by species like *Micromelum minutum* and/or *Glycosmis pentaphylla*.

That low closed forest is identified as the *Manilkara-Diospyros maritima* community to the fore on Turtell V Is. It could be considered a special case of the widespread monsoon vine forest but it seems restricted to the low wooded islands of the inner shelf of the northern GBR. On the tip of Cape York near Pajinka, the monsoonal vine thicket includes *Manilkara kauki* as well as *Terminalia muelleri* and *Mimusops elengi*: it looks closely related to the low closed forest reported here but without any detailed records to confirm this supposition, that parallel must remain speculative (Calvert 2006). On GBR coral islands, the monsoonal vine thicket stands out in contrast to the well-known and widespread *Pisonia grandis* forest and the equatorial *Terminalia-Neisosperma* tall forest (De Sloover 2003).

3.5.5.2. Shrublands

3.5.5.2.1. *Aglaia* closed shrubland. Beside the forest discussed in 3.5.3.1, extensive areas of a shrub community interspersed with restricted clearings occupy most of the higher parts of the cay and its lower slopes above the northern dead moat.

The community is often an open woodland where the scattered trees are of the same species as in the adjacent forest (table 11, columns 9 to 13). The shrubland cover is dense (90% as a mean) and can reach 100%. Most of its components are those belonging to the forest but with a higher frequency namely *Drypetes lasiogyna*, *Aglaia elaeagnoidea* and *Eugenia reinwardtiana* (fig. 33). When the cover is cut down (columns 14 to 16) some other shrubs like *Scolopia braunii* or *Capparis lucida* take over, but mainly species from the littoral scrub appear, such as *Premna serratifolia* and *Myoporum acuminatum* which are completely absent under the dense forest cover. In the same way, herbs like *Lepturus repens* and forbs win back lost ground but settle for the most part in the minute, enclosed clearings.

That shrubland looks like a primary community on thin soils above old high platforms along the northern dead moat but, in most cases, it could be a secondary one. On the higher areas of the cay right behind the *Casuarina* woodland, a poorly structured shrubland looks like the aftermath of a felled broadleaf forest. Shrubs thrive from ground shoots or runners and branching-out growth expresses that interference. Typical clearings are found behind the well and the foundations of a building that transient sea cucumber fishermen erected during the nineteenth century because they needed loads of firewood to boiling their sea cucumbers. Moreover a few *Manilkara* stumps still obvious in the nearby shrubland seem to bear out that practice.

That shrubland could be regarded as a special case of the more widespread monsoon vine thicket. On Turtell V Is, the main shrubland is characterized by *Aglaia elaeagnoidea* and *Diospyros compacta* (De Sloover & Dufrêne 1999). The latter species does not occur on Nymph although it is present in the littoral scrub. On Eagle cay, the shrubland is practically restricted to a littoral scrub with its usual components (De Sloover & Liégeois 1997).

Table 11. Specific composition and cover in the *Manilkara* low closed forest (col. 1 to 8) and in the associated *Aglaia* shrubland (col. 9 to 16).
Have been extracted from the table: T: *Mimusops elengi* 2, *Planchonella obovata* 1, *Premna serratifolia* + (col. 7); h: *Sarcostemma australe* +, *Xenostegia tridentata* +, *Carissa laxiflora* 1, *Diplocyclos palmatus* +, *Ipomoea macrantha* 2, *Abrus precatorius* +, *Tacca leontopetaloides* 1 (col. 7).
T: trees, Sh: shrubs, h: herbs or forbs, (j.): juvenile, (pl.): plantlet, l: climber.

Column Nr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T – Tree cover (%)	85	80	85	40	60	70	90	70	60	15	20	20	15	–	–	–
Sh – Shrub cover (%)	60	60	55	80	80	70	55	95	90	85	100	95	80	65	35	55
h – Ground cover (%)	35	30	50	35	15	15	35	15	45	30	35	8	30	30	30	10
Mean height: Trees (m)	6	5.5	6.5	6.5	4.25	4	7.5	8	5.25	5	6.5	5	5	–	–	–
Shrubs (m)	2.5	2.5	3.25	2.5	1.75	1.75	3.5	3	1.25	2	3	2	2	2.5	1.75	2
Herbs (cm)	25	25	15	30	30	30	30	30	20	40	30	15	25	10	10	20
Surface (sq.m)	400	200	250	200	250	250	200	200	250	200	200	250	300	150	400	150
Specific number	15	17	16	18	18	21	25	18	22	17	17	19	26	19	39	6
T *Manilkara kauki*	5	4	4	3	1	3	.	1	2	+	2	2	1	.	.	.
Aglaia elaeagnoidea	1	2	.	+	3	3	2	.	2	1	.	+	1	.	.	.
Drypetes lasiogyna	1	.	1	1	2	+	3	1	2	2	.	.	1	.	.	.
Terminalia muelleri	.	1	.	.	1	1	2	4	+	+	.	1	.	.	.	.
Vavaea amicorum	.	.	.	.	+	+	.	1	.	.	.	.	.	.	.	.
Chisocheton ramiflora	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
(l) *Opilia amentacea*	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.
(l) *Cappans sepiaria*	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
(l) *Sarcostemma australe*	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.
(l) *Ipomoea macrantha*	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Sh *Drypetes lasiogyna*	+	+	+	2	1	1	1	2	2	3	1	2	2	1	1	.
Aglaia elaeagnoidea	1	2	3	.	3	3	1	3	2	+	4	2	1	2	+	.
Eugenia reinwardtiana	1	+	1	3	2	1	+	3	3	3	1	4	3	1	+	.
Chisocheton ramiflora	3	+	1	1	2	2	.	1	1	2	2	+	2	1	+	.
Cassine melanocarpa	2	2	2	+	2	.	1	.	1	1	1	1	+	.	+	.
(l) *Hoya oligotricha*	1	+	1	2	+	2	.	+	1	1	+	1	1	+	.	.
Planchonella obovata	.	1	.	2	+	1	2	.	.	.	1	.	2	1	.	.
Celtis philippensis	+	+	+	+	+	+	2	+	+	+	+	+	+	.	1	.
Glycosmis pentaphylla	.	+	+	+	1	.	2	1	1	1	1	+	.	.	.	.

	Diospyros mantima	+	1	1	1	.	1	1	.	2	.	2	.	+	1	.	.
	(l) Opilia amentacea		+	+		1	+	+	+	+	+	+	+	1	.	.	.
	Capparis sepiana	+	+			+	+	1	+	+	.	.	+	.	.	+	.
	Polyalthia nitidissima	+		+	.	+	+	.	+	.	+	.	.	.	.	.	.
	Terminalia muelleri				+	+	+	.	.	.	.	.	.	2	1	2	.
	Scolopia braunii			.		+	+	.	.	.	.	+	.	.	3	.	.
	Capparis lucida			.	+	.	.	.	.	.	.	.	.	.	.	.	3
	Manilkara kauki			.	.	.	.	1	1	.	.	.	.	.	.	2	.
	Ixora timorensis			+	.	+	+	.	.	.	.	.	.	.	+	.	.
	(l) Abrus precatorius			+	+	+	+	.	.	+	+	1	+	+	+	+	
	(l) Sarcostemma australe	.	+	.	.	+	1	.	+	.	+	.	+	+	+	+	1
	Carissa laxiflora			.	+	.	+	+	.	.	.	+	.	.	.	.	.
	Vavaea amicorum			.	.	.	+	.	.	1	+	+	.	.	.	.	.
	Mimusops elengi	.	.	.	+	.	.	.	.	.	.	.	+	+	.	1	.
	(l) Flagellaria indica		.	+	.	.	.	1	.	.	.	.	.	+	.	.	2
	Cassytha pubescens			.	.	.	+	.	.	.	.	.	.	+	1	.	.
	(l) Ipomoea macrantha	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
	Premna serratifolia		.	.	.	.	.	.	.	.	.	.	.	+	+	1	1
	Myoporum acuminatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+
h	*Cyperus scaber*	.	.	.	.	.	.	.	.	+	.	.	1	1	2	.	.
	Lepturus repens	.	.	.	.	.	.	.	.	+	.	.	.	1	+	1	2
	Boerhavia albiflora	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
	Cleome viscosa	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	.
	Portulaca australis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
	Aglaia elaeagnoidea (j.)	2	+	+	.	2	.	2	2	1	2	2	+	.	.	.	.
	Drypetes lanuginosa (j.)	+	+	+	.	2	.	+	2	1	2	2	+	.	.	.	.
	Hoya oligotricha	2	1	3	2	1	2	+	+	2	2	+	1	.	2	.	.
	Eugenia reinwardtiana (j.)	1	.	.	2	+	1	+	+	.	1	.	1	.	.	.	.
	Glycosmis pentaphylla (j.)	+	1	.	.	1	.	+	2	.	.	+	+	.	.	.	.
	Planchonella obovata (j.)	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.
	Opilia amentacea (j.)	+	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.
	Flagellaria indica (j.)	+	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.
	Vavaea amicorum (pl.)	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
	Dioscorea bulbifera	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.

On the driest soils, namely south of the dead moat edge on the rocky upper platform, the soils are quite thin and the *Aglaia* shrubland turns into an open scrub on which only the most xerotolerant species survive (table 11, column 16).

3.5.5.2.2. *Capparis lucida* open scrub. Behind the highest northeastern shingle ridge, a quite different drought-tolerant scrub settles in the hollows where thick pumice deposits have accumulated. This infrequent low open scrub shows a sparse herb layer. In the shrub layer, *Capparis lucida* cover reaches 25 to 50%. The only relevé that was taken on 150 sq.m is as follows:

Shrub layer (cover: 55%/h.: 2 m)		Herb layer (cover: 10%/h: 20 cm)	
Capparis lucida	3	*Lepturus repens*	2
Flagellaria indica	2	*Commelina undulata*	+
Premna serratifolia	1		
Sarcostemma australis	1		
Myoporum acuminatum	+		
Carissa laxiflora	+		

3.5.6. Sand cay soils

Close examination of soil profiles on the four recognized terraces of the sand cay revealed the main features of the soils sampled within vegetation plots. The first two terraces are covered with typical *Casuarina* woodland, the third one with thinner woodland associated with an understorey of dense broadleaf shrub, a transitional step to the next terrace. The fourth terrace is dominated by the broadleaf *Manilkara* low forest (fig. 37).

The profiles are of young soils of a maximum depth of some 40 to 50 cm. If such sandy permeable soils had a longer history, they would have become much deeper and differentiated in the same way as those developed on the quartzose sand of the Cooloola (South Queensland) dune systems which are more than 30,000 years old and deeper than 20 m (West & al. 1981).

Under the woodland, *Casuarina* litter (A_0 layer) lies apparently undecayed or anyway without a typical decomposed layer under the fragmented layer. Its mean thickness is close to 2 cm but varies greatly from place to place from a few mm to some 5 cm (table 12). The build-up of that *Casuarina* brittle litter looks quite patchy due to the openness of the undergrowth and, mainly on terrace II, to disrupting tramplings. Close by the shore, wind deflates that soft, unfragmented litter and the underlying sand, so that litter does not pile up evenly and cannot be used as a sign of the time interval that has elapsed. Furthermore, given the decreasing primary productivity, Terrace III displays the thinnest litter. In spite of the apparent litter instability, decay does occur and organic matter in the upper sand layer (A1 layer) is incorporated and builds up the storage layers (Ah horizon).

Mineral substrate consists of coral sand deposits, generally clear yellow to beige in colour and of coarse structure, possibly including unrefined animal debris, like shells and coral fragments. The original sand layer can be reached by digging deep enough to avoid the alterations that have taken place under the effects of incorporated matter. In between

Table 12. Soils characteristics on the four successive terraces and the different horizons.

Data are shown with means ± standard errors; N = number of samples.

Results from two-way Anova (F, p).

Soil horizons	Parameters	Successive terraces				F p between terraces
		Terrace I	Terrace II	Terrace III	Terrace IV	
	N	10	8	8	15	
A0	Thickness (cm)	2.3 ± 0.6	1.1 ± 0.5	1.4 ± 0.8	2.8 ± 0.3	2.85 0.0539
A	Thickness (cm)	1.8 ± 0.3	1.9 ± 0.5	2.6 ± 0.8	2.5 ± 0.4	0.38 0.7654
	pH	8.2 ± 0 2	8.7 ± 0.1	8.5 ± 0.2	7.6 ± 0.1	12.69 < 0.0001
	Conductivity (µmho.cm-1)	401.0 ± 206.4	164.9 ± 50.2	198.0 ± 96.6	560.1 ± 94.7	3.26 0.034
	O.M. (%)	6.6 ± 3.2	1.6 ± 0.2	4.9 ± 2.5	21.3 ± 1.7	28.00 < 0.0001
Ah	Thickness (cm)		12.5 ± 6.2	18.9 ± 3.4	18.5 ± 1.8	0.82 0.4548
	pH		8.7 ± 0.2	8.6 ± 0.1	8.3 ± 0.1	5.60 0.092
	Conductivity (µmho.cm-1)		130.5 ± 24.9	124.0 ± 26.1	181.4 ± 24.5	2.18 0.1320
	O.M. (%)		3.5 ± 1.8	1 8 ± 0 2	5.9 ± 1.3	2.15 0.1352
(C)	Thickness (cm)	4 4 ± 1 1	14 4 ± 3 8	25.3 ± 3.6	23.4 ± 1.3	15.64 < 0.0001
	pH	9 0 ± 0 1	9 0 ± 0 1	8 9 ± 0 1	8.9 ± 0.02	0.51 0.6809
	Conductivity (µmho.cm-1)	88.8 ± 16.8	67.7 ± 10.0	87.5 ± 21.1	64.1 ± 3.0	1.28 0.2998
	O.M. (%)	0.8 ± 0.3	0.6 ± 0.1	0.6 ± 0.1	0.5 ± 0.04	0.85 0.4774
F p between horizons	Thickness	2.92 0 0847	5.64 0 0062	22.90 < 0.0001	64.17 < 0 0001	
	pH	8.20 0.0118	2.53 0.111	3.03 0.0723	75.32 < 0.0001	
	Conductivity (µmho cm-1)	2.78 0.1299	1.61 0 2327	0.75 0.4849	23.41 < 0.0001	
	O M (%)	3 63 0 0759	4 16 0.0352	2.06 0.1536	69.35 < 0.0001	

the soil surface under the litter and that level, changes have taken slowly by transfer of the substances contained in the litter (table 12).

The first phase of this process of change is a bleaching of the superficial sand layers that fade from beige to light grey. At the same time, organic fragments, still crude, are

incorporated into the sand in the form of black micropellets, but pH and electrical conductivity remain roughly unchanged. That process has been observed in the soil profiles carried out on the first three terraces, namely Terraces I, II and III. The fading of the sand to a grey colour is even more obvious in profiles carried out from Terrace I to Terrace III and directed to increasingly deeper layers (table 12). The depth of the bleaching on Terrace III is exceedingly variable and could be as much as 35 cm (as a mean 24 cm). The soil looks quite different on Terrace IV with its broadleaf forest cover. pH values in horizon A clearly decrease while electrical conductivity increases, the presence of organic matter rises dramatically to more than 20% and in most cases a raw humus layer has developed, sometimes as deep as 5-6 cm.

Under that first mineral horizon, a second one including storage layers comes to light except on Terrace I where a beige to pale yellow colour typical of horizon C is restored at once. As opposed to Terrace I which is characterised by a young soil (AC soil), on Terrace II and more notably on Terrace III, grey to deep brown or black shades are frequent. On Terrace III at a depth of between 5 and 30 cm, dark shades become even stronger, deep brown being the pre-eminent feature conveying the plausibility of hemi-organic layers.

Soil profiles end with the bedrock consisting of the original coral sand deposit. That C horizon is located at increasing depths depending on soil age i.e. from a mean of 4.5 cm on Terrace I to more than 25 cm on Terrace IV under the *Manilkara* forest. In C horizon, pH values stay around 9.0 or slightly less. Organic matter content stands below 1% but this value is the lowest in that horizon under the forest soil surface (table 12).

The spectacular increase in organic matter along the soil profile and its accumulation in deep horizons is not gradual from the shoreline to the inland woodland. It clearly proceeds in jumps and starts and seems linked to the successive terraces that have been constructed throughout the last millennium.

Finally, let us recall the charcoal pieces found within a dark coloured horizon on Terrace II at a depth of some 30 cm and dating from 400 BP. They probably bear witness to early human activities including cooking fires (cf. Part I. — 1.4. Human factors). Fresh sand deposits could have buried these old surface horizons.

Part 4

Plant communities and geomorphology, an overview

4.1. Successional development

4.1.1. Soil heterogeneity and maturity increase in time. A supply from the vegetation organic matter is essential to support that process on Nymph's poor coral sandy soils devoid of the most essential nutrients except Ca, which is superabundant although mostly in ineffective chemical forms.

A succession of plant communities has already been suggested as affecting the first classical pioneering seral stages leading to the littoral shrubland. However, the part played by *Casuarina equisetifolia* during that evolution has always remained obscure or been misunderstood. This is the main subject to be discussed here concerning Nymph Is cay because it is one of the best spots to scrutinize the dynamic process involved. Elsewhere on nearby islands like the Turtell Group or Eagle Is, that process seems to have been sidestepped or is at least very incompletely for lack of a comprehensive geomorphological sequence.

Plant pioneers on fresh sand deposits are generalists that stabilise the substratum and establish the upper beach herbfield as the first plant community. Juvenile shrubs like *Argusia* or *Scaevola* settle early among forbs and grasses. *Casuarina* does not occur as regularly as the former during these initial stages. If this species really takes place, it can be massive and owing to its fast growth, it quickly grows into a thicket as it did at the rear of the latest beach created near the southern tip of the sand cay. Abundant litter and shade progressively eliminate most forbs and young shrubs. Indeed, it often happens that *Casuarina* itself is the first invader. That classic scheme seems implicitly accepted.

The next step in that succession is less well understood. As described above and as time goes by, the mature *Casuarina* woodland grows thinner in the end as on the third terrace (table 7, columns 16-22). Broadleaf shrub species are below the upper canopy and build up a dense understorey involving the same tree species that will fully occupy the area during the next step. Indeed, on the oldest terrace among mature *Manilkara* forest plots, some old *Casuarina* clumps still survive and attest the past history at a time when *Casuarina* trees invaded a freshly deposited beach.

We believe that, from the pioneering foredune herbfield to the *Manilkara* dense forest following the receding sea on the successive terraces, the evolutional chain goes through the successive stages of littoral scrub and *Casuarina* woodland. That primary succession was only made possible by the geomorphological evolution of the cay and the time interval. This is a typical primary succession leading to the floristic and structural complexity of a self-perpetuating climax

4.1.2. On the eastern old high shingle ridges, *Lepturus* grassland settles and, in time, very slowly accommodates sparse shrubs and small trees. Primary succession however seems

to have been inhibited beyond that point or at least dramatically slowed down and apparently stabilised. This standstill has to be ascribed to climate as well to soil conditions; on these high windswept ridges made up of coarse juvenile substratum, shrubs and trees do not prosper and only the few that manage to withstand these extreme factors get established. They form at best an open shrubland although they can thrive on the leeward reverse of the woodland crest facing the central lagoon (fig. 35).

4.1.3. Mangals cast doubt on traditional successional schemes of which the zonation of mangrove communities in response to subtle topographical or edaphic differences are the most striking feature and should not be interpreted as a succession of seral stages but rather as a response to geomorphological and or drainage micro-differences. On Nymph

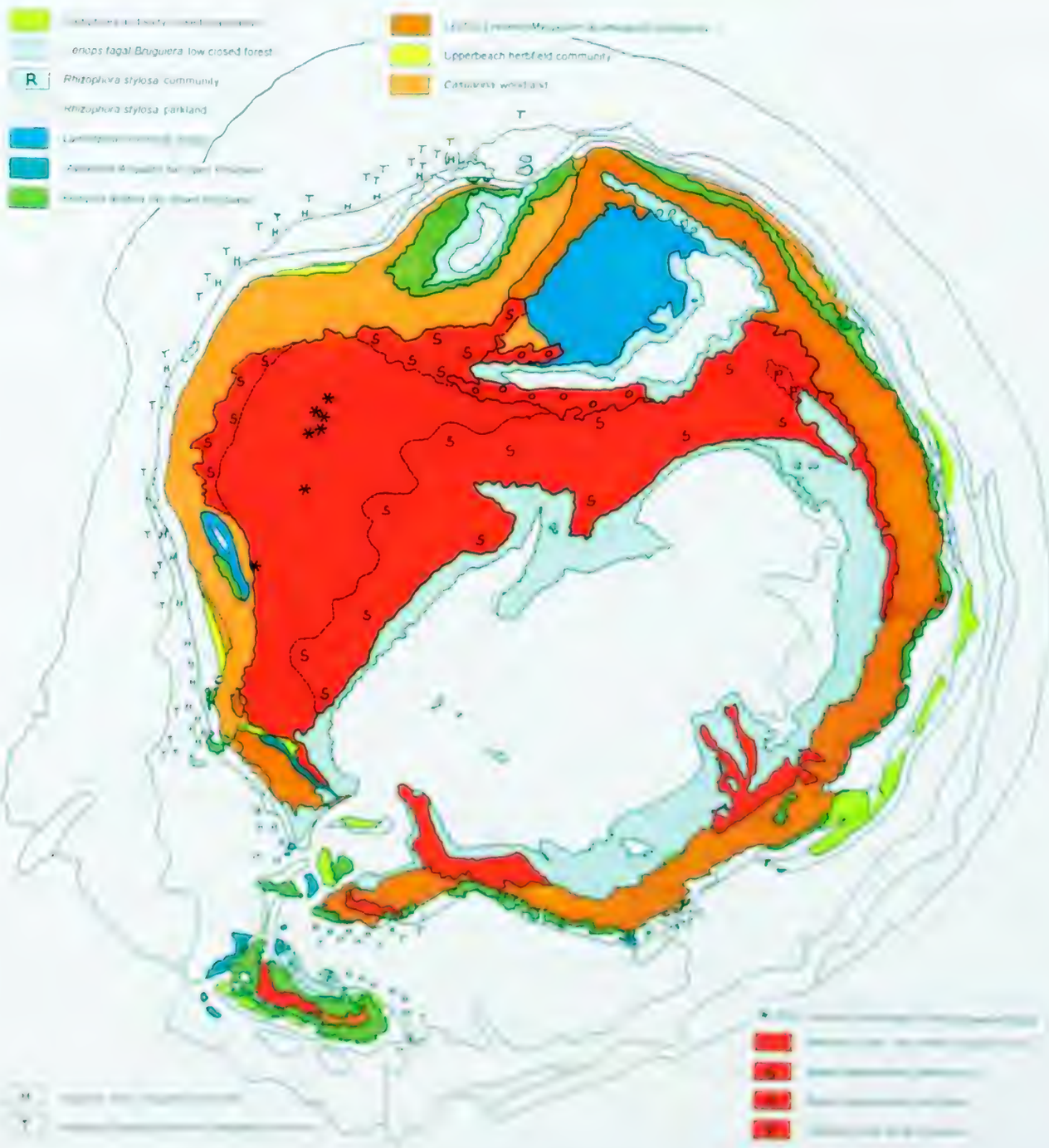
eriops fagal Bruguiera low closed forest
R Rhizophora stylosa community
Rhizophora stylosa parkland
Upperbeach herbfield community

Figure 35. Distribution of sixteen vegetation units on Nymph Is.

Is, the zonation of mangals is barely discernable and their distribution seems designed to meet the specific requirements of each of them.

4.2. Graphic expressions of vegetation distribution

Two graphic expressions illustrate the distribution of the plant communities.

4.2.1. Mapping the vegetation units. After delimiting the vegetation units and their habitat, the next step gives an overview of their actual distribution on Nymph Is and their link(s) to the physiographic factors they share. This goal is best achieved by mapping the extent of the recognized vegetation units.

4.2.1.1. Methods. Photo patterns recognized on black and white and on colour vertical aerial photography (Dept. of Lands, Cairns to Cormorant Pass Project, Q 4072 Run 8 Ph. nr 122) were used with ground controls to map the apparent limits of the recognized vegetation units as specified in tables 1 to 11.

Given reproduction scale selected, vegetation subunits or variants are omitted as well as some vegetation units, *Capparis lucida* shrubland for instance, because their extension is exceedingly restricted. Samphires and in a few cases mangal communities are grouped as if they were global physiognomic entities and not the acknowledged communities as validated by tables and descriptions: the intricacies or mosaic patterns of these communities make it impossible to reproduce their spatial arrangements. In the same way the subassociations as observed in the tussock grassland have not been indicated. Small spots of *Sorghum* grassland enclosed in a clearing at the outer edge of the *Casuarina* woodland do not appear on the map either.

Furthermore, the three *Casuarina* woodland subdivisions linked to the presumed successive terraces are only demarcated on fig. 37 by dashed contour lines suggesting the successive terraces.

4.2.1.2. Results and discussion. In spite of these simplifications, the unit outlines of the vegetation map often overlap (fig. 35). The intricacy of the island's physiographic history that was shaped in fits and starts over the last few thousand years and has demarcated tiny vegetation fragments enclosed within larger unrelated units. Generally speaking, these enclosures or finger-like extensions were so minute they could not be inserted on the map although they would have contributed to the interpretation of the island's history.

Furthermore, the outcomes of our mapping show the extent to which the existing maps are incomplete and even seriously inaccurate, not only as regards the plant communities and their spatial distribution but also about Nymph's geomorphological features (fig. 1).

Although the topographic and vegetation map published by Smith (1994) is quite sketchy, it is the best or the least erroneous map available so far (fig. 1C): woodland and herbland are the only large physiognomic units recognized while mangals and samphires are omitted. 'Sparse woodland' roughly indicates the *Casuarina* woodland while 'dense woodland' encompasses the *Manilkara* broadleaf forest along with all kinds of mangals. Although herbland properly speaking covers the whole easterly shingle ridges, it also refers to the entire satellite southern islet that is almost completely devoid of grassland. However, moats and lagoons are rightly located for the first time.

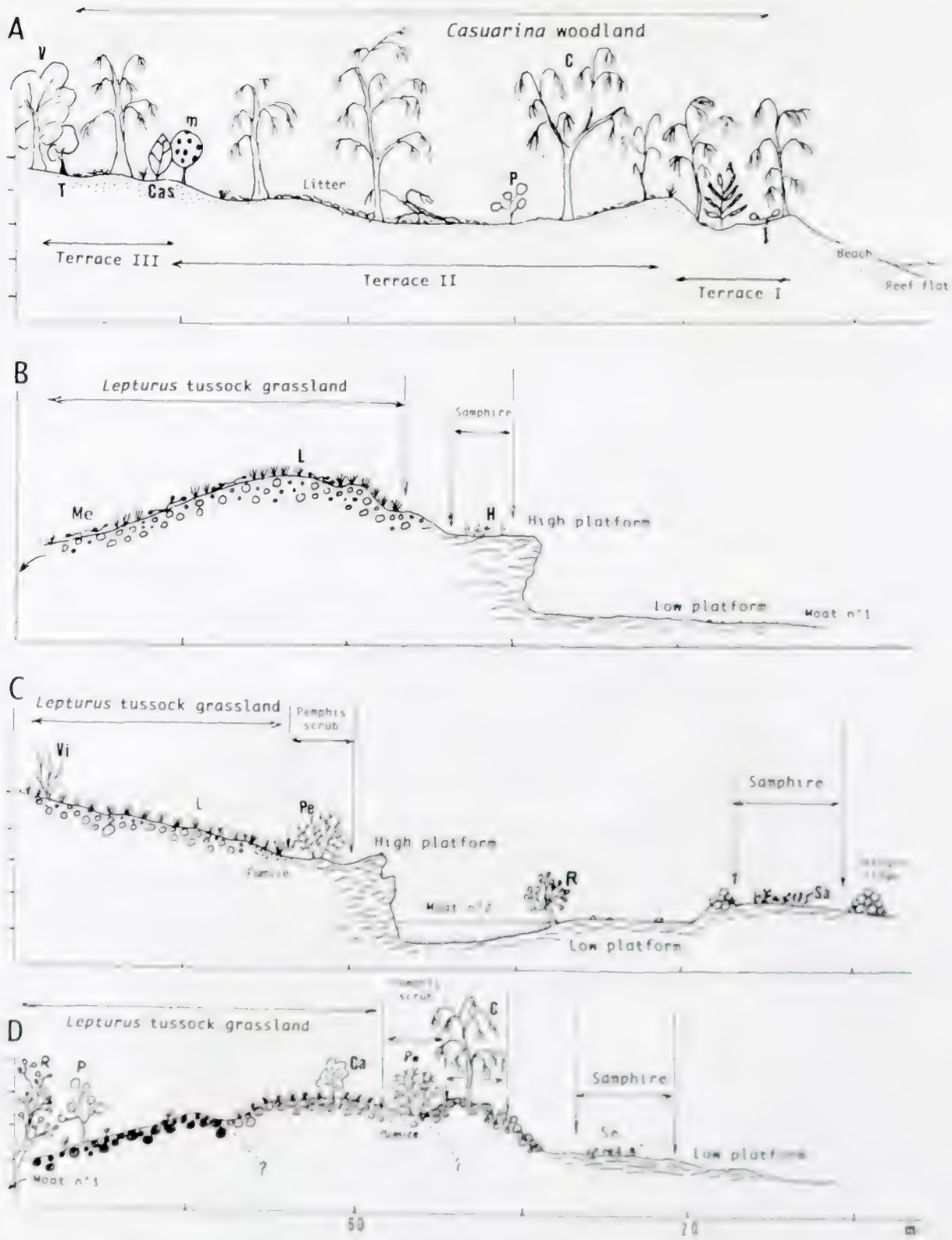

Figure 36. Transects illustrating the sharply contrasting topography and associated vegetation features on Nymph Is (for locations see figure 37)

A: transect of the eastern sand cay from inner reef flat to monsoon vine forest beyond Terrace III

B: transect on the southern shoreline, from moat nr1 through low platform, cliff and upper platform to Lepturus *grassland on shingle*

C: transect from the southwestern shoreline through samphire, low platform, moat nr 2, cliff, upper platform and grassland on shingle ridges

D: transect from the northwestern shoreline with platform and samphire, successive shingle levees to the mangrove around moat nr 3. A: Argusia argentea, C: Casuarina, Ca: Capparis lucida, Cas: Cassine melanocarpa, L: Lepturus repens, m: Mimusops elengi, Me: Melanthera biflora, P: Premna serratifolia, Pe: Pemphis acidula, R: Rhizophora stylosa, Sa: Sarcocornia quinqueflora, Se: Sesuvium portulacastrum, T: Terminalia muelleri, V: Vavaea amicorum

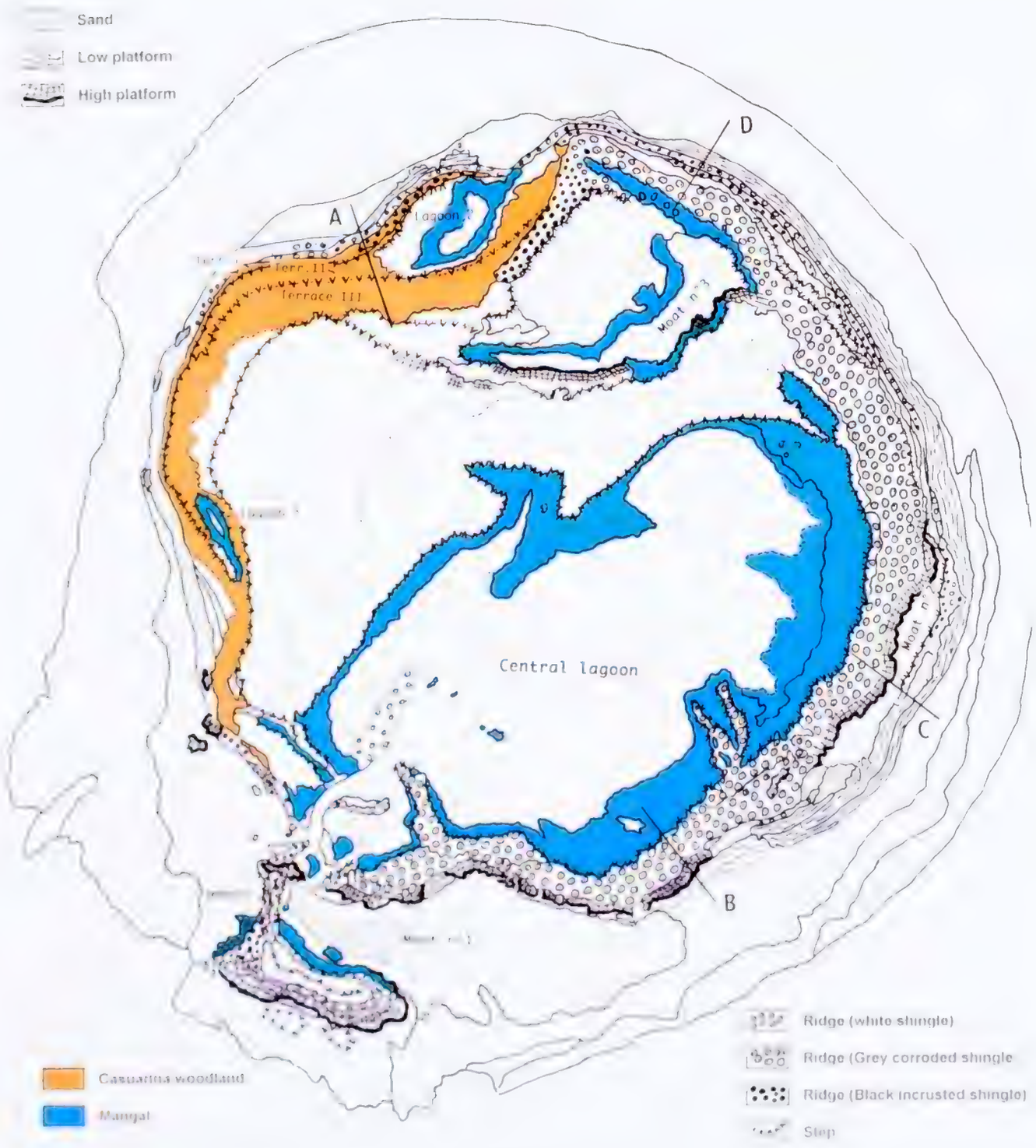

Figure 37 – Geomorphological map of Nymph Is including the distribution of mangals and, on the sandcay of Casuarina woodland (with terrace contours as detected approximately)
The lines A, B, C & D indicate the position and direction of the transects depicted in fig. 36

The map provided by Flood (1984) to the Australian Sedimentologists Group, is less to the purpose (fig. 1B). At the time it was made, aerial photographs were already available and the delineated contours suggest they were used. Unfortunately, most of the reported facts are unusable: captions on the map indicate mangroves when in fact broadleaf forest covers the sand cay; 'undifferentiated vegetation' incorporates the *Casuarina* woodland as well as mangals, grasslands or *Pemphis* scrub; the 'pool' is a dead moat and the 'cemented

platform' which in fact runs alongside the southern border of the so-called 'pool' wrongly extends to the northern tip of the island, and so on. So many inaccuracies are quite incomprehensible.

Steer's old map (1938) made by pacing and compass bearings (fig. 1A) is by far more instructive than the former. The sand cay and its *Casuarina* woodland were accurately designated, 'sand and shingle flora' as well as 'mangrove swamp' and 'moat' were correctly placed, given the means available.

4.2.2. Vegetation transects

In order to refine the distribution achieved by mapping the vegetation units, transects were conducted to enhance the perception of some aspects of the vegetation in relation to topography. The four selected transects are not idealized vertically but are drawn to scale in keeping with land surveys made with a levelling gauge. Their position and direction are reported on the map in figure 37.

The first transect is marked out on the western shore through the sand cay from the shoreline to the broadleaf central forest. By comparing figures 36A and 37 we could detect the faint steps along the slope between the high water mark and the central forest. They more or less clearly demarcate the successive 'centrifugal' terraces overgrown by new settings of *Casuarina* on each of the freshly deposited terraces. From the mature *Casuarina* woodland on Terrace II to the *Manilkara* monsoon forest on the top of the sand cay, transitions occur, with increasingly open canopy and more numerous shrubs in the understorey. Several components of the monsoon vine forest (for example *Terminalia muelleri*, *Mimusops elengi* and *Cassine melanocarpa*) overrun the woodland as a pioneering shrub species while littoral scrubs like *Argusia argentea* disappear.

The second transect (fig. 36 B and B on fig. 37) is traced from the southern shore and starts in moat nr 1, then runs across the low platform and the cliff under the high platform through the narrow *Pemphis* scrub ribbon. It climbs again across the *Lepturus repens* - *Wedelia biflora* tussock grassland to the top of the highest shingle ridge.

The third transect (fig. 36 C and C on fig. 37) runs a little further north across the southwestern shore. It crosses the *Sarcocornia quinqueflora* samphire on low platform, through moat nr 2 lined with *Rhizophora*, the cliff under the high platform, the *Pemphis* scrub and the *Lepturus* tussock grassland with its scattered shrubs.

The fourth one (fig. 36 D and transect D on fig. 37) starts on the western low conglomerate platform (with samphire) and runs westwards across the successive shingle ridges that pile one above the other. On the first ridge, it meets the *Casuarina* thicket, then the open *Lepturus* grassland and associated shrubs. On the leeward slope, the edge of the last ridge on the transect joins the mangal lining the dead moat.

4.3. Genesis of the island structure: a reappraisal

When drawing the vegetation contours and conducting step-by-step ground controls to the boundaries between adjacent vegetation units, many geomorphological and pedological features came to light. Our aim was to link plant communities to soil configuration, not to obtain fully documented geomorphological data. This approach arose as a by-product that would supplement the scanty geomorphological data available. A new but still provisional geomorphological map is therefore presented (fig. 37).

4.3.1. The sand cay

Delineation of the sand cay contour line is like a palimpsest: it accounts for the most changing feature of the island in the recent time.

On the mid-western side, the shoreline is now in a relatively stable and the high water mark abuts on the *Casuarina* woodland fringe. The foredune herbfield and/or the littoral scrub that are successively the forerunners of the woodland were obliterated by syndynamic evolution.

In contrast, towards the southern end of the sandy cay a large bay carved out by sea currents is now silting up with sand. At the rear of the beach, the *Ipomoea* community is establishing itself while, behind that pioneering vegetation, a dense *Casuarina* thicket has already developed. That set of communities are proof of the most recent accretion to the island, coupled up with the deep erosion to which the northern tip has been subjected.

Unlike that silting process, severe erosion of the shore is underway toward the northeastern limit of the cay. A well-established shingle ridge is being gradually eaten away and its plant cover will disappear with it. This explains why remnants of the *Pemphis* scrub that covered the coral ridge now appear on the reef flat as a vestige of the old scrub (fig. 22 & 23). Furthermore, the small closed lagoon that was trapped behind the remains of the shingle levee will probably be unbolted: its mangrove will then be in direct contact with seawater to form a small bay lined with *Rhizophora*. It must be pointed out in this connection that the pH and conductivity of that mangrove water which were recorded respectively at 8.04 and 986 µmho.cm^{-1} are nearing those of sea water (8.04 and 970 µmho.cm^{-1}). Exchanges between the lagoon and sea at high tide are probably already filtering through the loose coral rubble. Eventually that small pool (pool nr 2, fig. 37), one of the last to have been fashioned, will probably disappear.

4.3.2. Lagoons and moats

The main central lagoon (lagoon nr 1, fig. 37) is unique among low wooded islands. The standard lay-out consists of leeward sand cay, clearly separated from the windward shingle ridges by a large reef flat at least partly occupied by mangals.

The central lagoon is quite shallow on Nymph Is at low tide and its bottom is lined either with carbonate mud or with coral sand supporting *Halimeda* and *Chlorodesmis* populations which grow better here than on the reef flat. These algae have thick stipes completely buried in soil and impressive tufts of blue green spreading thalli. In spite of the contact with the ocean through the western channel, the waters show a slightly higher salinity than the sea with electrical conductivity reaching 1025-1030 µmho.cm^{-1} vs. 970.

Considering the small size of the old Holocene reef, the sand cay that is the most recent island feature seems to have settled at an unusually short distance from the windward ridges. The in-between space that is normally devoted to a bare reef flat lies protected here, not only by the massive shingle ridges but mainly by an old high platform which makes up a glacis against the easterly storms. Are these features sufficient to explain the persistence of a shallow lagoon that fills up when the tide comes in and empties at ebb tides?

Other lagoonal features are also noteworthy. Opened up by the erosion of the coral rubble ridge, the small northern lagoon is more recent by far. It was shut off from the sea when the island's northern tip stockpiled tremendous amounts of sand and coral rubble which not only isolated the old dead moat (moat nr 3, fig. 37) but also the *Lumnitzera*

mangal extending to the northwestern edge of that moat (fig. 35). Day by day the closeness of the small northern lagoon to the sea increases water exchanges through the thinning coral levee.

A tiny and probably even more recent lagoon (lagoon nr 3, fig. 37) that supports a *Lumnitzera* mangal occurs behind the spot where the sand finally filled in the bay which used to form a notch at the southern tip of the cay (cf. 4.1 above). Shallow waters waver between a high stand during high tide and a low one at ebb tide. However, in spite of that link, they are spoiled and their conductivity is as high as 1360 µmho.cm^{-1}. That value is a point in favour of their partial isolation.

4.3.3. The high 'raised' platform

Evidence of sea level 2-3 m higher than at present, the high platform acts as an efficient rampart against the southeastern gales. The carved cliffs are pitted by erosion and their projecting karstlike ledges protect the main lagoon from being wiped out by exceptional storms.

Remnants of that 'raised' platform can still be seen along the western sand beach north of the exit channel from the main lagoon, i.e. far apart from the main cliff lining the southern moats. From this, its last typical site, it extends along the eastern shore bordering the moats that are still in contact with seawater at high tide. Further north, it remains shrouded under the huge shingle ridges. It nevertheless reappears at the level of what is known as a 'pool' on Flood's (1984) map. At this level, the raised platform turns westward where it first borders on its southern shore of the so-called 'pool' that is in fact an ancient moat which has lost its attributes. This approach to the geomorphological configuration of Nymph Is entails major repercussions on the interpretation of the island dynamic.

Still lined at least in part with *Rhizophora*, that fallen moat does not freely exchange water with the nearby sea. This body of water turns out to be more concentrated (up to 1150 µmho.cm^{-1} as against seawater that stays around 970). The high conductivity values that were achieved in September before complete drying out in January suggest that severe evaporation is taking place. The moat is obviously devoid of corals and other forms of life that must have been common when the moat was connected to the ocean. Its isolation means that that the water level is maintained to some extent by slow infiltration from the reef flat through the piled-up coral rubble of the eastern ridges and by rainwater for most of its expanse. So it is more than a standard pool, rather a real moat that gradually disappears as a result of the island's evolution. At the western tip of that moat, the raised platform seems to carry on under the sand cay. Only drillings could test this hypothesis of a further extension of the high platform linking up with the remnants already reported of the western beach.

If this hypothesis proved correct, the whole genesis of Nymph Is would have to be reconsidered. When sea level was, as it seems, some 3 m higher than at present, the island would have been smaller, its area being limited to the main lagoon surrounded by shingle ridges that were later cemented to give way to the present high platform. Still attesting that stage of the island history, the present dead moat (moat nr 3) ran as a living moat alongside its northern shore and the whole area beyond it was evidently built later on the reef flat. When sea recession began, the high platform acted as a wall against storms and was partly dismantled or buried under new supplies of shingles.

4.3.4. The windward shingle ridges

The impressive shingle ridges that have accumulated on the eastern shore tell us more about the island's history.

Moving from the outer reef towards the shoreline, the first shingle ridges to be encountered are small parallel heaps of coarse white coral rubble. They are awash at every high tide and move easily from one tide to the next. Between these incipient ridges and the very base of the spectacular stack of coral shingles, that is barely touched by high tides, stretch the reef flat and the so-called promenade that represents the old eroded platform. On Nymph Is, this platform is the elective habitat of samphires immerged at each tide.

The most informative coral ridges are those beyond the reach of the tides. They were gradually piled up and built over thousands of years. As hard-consolidated structures, they surmount the high platform by about 1 m. The higher one rises some 3 m above the reef flat [5], that is to say, to about the same height as the highest point (2.80 to 3.30 m) of the sand terrace on the leeward cay. The shingles of that crest were thrown up there when sea level was at its highest point some 5,000 years ago. They are now a dark shade and incrusted with blue-green algae. On the flank of that old deposit turned towards the sea the one immediately lower is grey in colour: its constituents manifestly accumulated there at a later stage. Like the earlier deposits, they are covered with scrubby grassland. Further down, the most recent deposits are still faintly coloured and colonized by the fringe of *Pemphis* scrub that mostly takes root in the underlying reef flat.

Shingles taken from each of these three levels should be analysed in order to date more precisely the three phases of successive ridging.

4.3.5. Shoreline evolution

Compared with the western shore, the windward shoreline looks relatively stable. This paradoxical situation stems from the nature of the shore, which from the southern tip of the island onwards is made up of the hard rock of the so-called high raised platform combined with the low platform material. The mechanical resistance thus provided to the windward shore is also at work further north where the huge shingle ridges only contribute to the island's expansion in a limited way. The redistribution of sandy material and even of coral rubble continuously restructures the leeward shoreline, from about the lagoon exit in the south to the northern tip of the island. Steady states are short events even if no new materials are added to the island.

The relatively recent signs of remodelling are self-evident but older shorelines linked to the progressive lowering of sea levels may not be directly inferred from today's vegetation except for the *Casuarina* woodland. In its geomorphological evolution, several successive shorelines seem to have followed the lowering of sea levels for at least the last 3,500 years. The oldest shoreline could be the one that formed the upper sand terrace, as confirmed by the presence of the oldest *Casuarina* trees still thriving in the *Manilkara* forest. The second shoreline seems to have closed up around the *Casuarina* population on Terrace III (and probably Terrace II) and, moving further north, now encloses the old moat and some of the innermost grey high shingle ridges. When the sea neared its present level, a third shoreline completely isolated the two small lagoons (lagoons nr 2 and 3) near the

[5] According to our own surveys made with a levelling gauge, the southern upper ridge tops are 2.35 to 2.95 m in height while the northern ones are 2.25 to 2.45 m.

western shore and stopped at the foot of the most recent terrace supporting the youngest *Casuarina* woodland (fig. 37).

It must again be emphasized that our hypothesis on shoreline evolution and island genesis is based on vegetation evidence linked to the substratum characteristics where they originate. The hypothesis would have to be legitimated through geomorphological analysis and dating.

Epilogue

Our project aimed to make a detailed inventory of plant communities, their habitats and relationships to island geomorphology. Our results finalised earlier projects, on Eagle Is, which is quite different in nature and origin, and on Turtell V Is that acted as a revealing miniature, opening the way to the Nymph Is study and its complexity.

The results from Eagle and Turtell V islands provided an up-to-date floristic assessment that was essential before we could begin to define Nymph's plant communities. At first the checklist was limited to trivial species, i.e. those occurring on most GBR coral cays, but it has now become one of the most extensive on the richness of Australian coral islands.

Most mangal communities along with *Casuarina* woodland and *Lepturus* tussock grassland are widespread on coral cays and on low wooded islands. But here on Nymph Is, they have reached their most significant structure and composition that have now been closely examined for the first time. Furthermore, the *Manilkara* broadleaf low closed monsoon forest seems unique and confined to the largest islands of the Turtell Is group and possibly to the nearby low wooded islands. From the point of view of biodiversity, Nymph offers a uniquely specific assemblage which in our opinion remains unrivalled. Moreover, the detailed study of *Casuarina* woodland suggests the progressive establishment of that community, on the assumption that first of all successive waves of *Casuarina* seeds encroached and germinated on shorelines as they were washed up on high watermark, second that new sand terraces, formed by each receding seawater level, were the gathering places of these progressive colonisations.

Mapping the extension of every plant community on the island was an essential step to learning about the relationships of plant associations with soils and geomorphological features.

Systematic controls of the limits of plant communities in the field, unexpectedly supplied new geomorphological insights into the extension of the high rock platform as well as the movements of shorelines. These findings constitute a new model for an understanding of coral island structuring.

Based on the present results, environmental management planning ought to be made. That essential outcome should be conducted to prevent a loss in the biodiversity and to maintain the nowadays high standard (Neil 2000).

References

Batianoff G.N. & Dillewaard H.A. (1988) Port Curtis district flora and early botanists: IV + 122 p. Indooroopilly, Queensland Dep. of Primary Industries.

Beadle N.C.W. (1981) The vegetation of Australia: 690 p. Stuttgart, G. Fisher.

Beaton J.M. (1978) Archaeology and the Great Barrier Reef. *Phil. Trans. R. Soc. Lond.* **B 284**: 141-147.

Bridges K.W., Phillips R.C. & Young P.C. (1982) Patterns of some seagrass distributions in the Torres Strait, Queensland. *Austr. J. Mar. Freshwater Res.* **33**: 273-283.

Bridgewater P.B. (1971) Practical application of the Zurich-Montpellier of phytosociology. *Proc. Roy. Soc. Victoria* **84**: 255-262.

Bridgewater P.B. (1982) Mangrove Vegetation of the Southern and Western Australian Coastline. P. 102-120 in: Clough B.F. Mangrove ecosystems in Australia. Structure, function and management: 302 p. Canberra, Austr. Nat.Univ. Press.

Brummitt R.K. (1992) Vascular Plant Families and Genera: 804 p. Kew, Roy. Bot. Gardens.

Buckley R.C. (1982) Patterns in north Queensland mangrove vegetation. *Austr. J. Ecol.* **7**: 103-106.

Bunt J.S. & Williams W.T. (1980) Studies in the analysis of data from Australian tidal forests ('mangroves') 1. Vegetational sequences and their graphic representation. *Austr. J. Ecol.* 5.: 385-90.

Calvert G. (2006) Plants of the Tip of Cape York. http://savanna.org.au/qld/cy/cyplants.html

Chapman A.D. (1991) Australian Plant Name Index. Australian Flora and Fauna Series, no.12- 15: 3055 p. Australian Biological Resources Study, II. Canberra.

Chapman V.J. (1975) Mangrove vegetation : 425 p. Lehre, J.Cramer.

Coles R.G., Poiner I.R. & Kirkman H. (1989) Regional studies – Seagrasses of north-eastern Australia. Chapter 9: 261-78. In: Larkum A.W.D., McComb A.J. & Shepherd S.A. (eds.) Aquatic Plant studies 2. Biology of seagrasses: XXIV + 841 pp. Amsterdam, Elsevier.

Davie J.D.S. (1987) Mangrove ecosystems in Australia, in Field C.D. (ed.), Mangrove ecosystems in Asia and the Pacific. Status, exploitation and management. Proc. Res. Dev. Seminar, Inst. Marine Sc., Townsville, Australia, 18-25 May 1985: 3-23.

De Sloover J.R. (2003) Terrestrial vegetation patterns and plant communities on Pacific coral cays. *Scripta Bot. Belg.* **24**: 155-167.

De Sloover J.R. & Dufrêne M. (1999) Flora and vegetation of Turtell V, Turtell Islands Group (Queensland, Australia). *Bull. Jard. Bot. Nat. Belg.* **67**: 45-97.

De Sloover J.R. & Liégeois S. (1997) Eagle Island flora and vegetation (Queensland, Australia). *Bull. Jard. Bot. Nat. Belg.* **66**: 347-383.

Duke N.C. (1991) A systematic revision of the mangrove genus Avicennia (Avicenniaceae) in Australasia. *Austr. Syst. Bot.* **4**: 299-324.

Du Puy D.J. & Telford I.R.H. (1993) Flora Australia Vol. 50, Oceanic islands 2. Canberra, Australian Gov. Publ. Serv.

Flood P.G. (1984) A geological guide to the Northern Great Barrier Reef. Austral. Sedim.Group; Field Guide Ser.1: 100 p. Geol. Soc. Austr.

Fosberg F.R. (1976) Coral island vegetation, in Jones O.A. & Endean R. (eds.), Biology and geology of coral reefs 3 (Biology 2): 255-277. New York, Academic Press.

Fosberg F.R. (1978) Studies in the genus Boerhavia L. (Nyctaginaceae). *Smithsonian Contr. Bot.* **39**: 5-8.

Fosberg F.R. (1988) New and noteworthy plants from Great Barrier Reef sand cays, Australia. *Brittonia* **40**: 52-65.

Fosberg F.R. & Stoddart D.R. (1991) Plants of the reef islands of the northern Great Barrier Reef. *Atoll Research Bull.* **348**: 1-82.

Harden G.J. ed. (1990-1993) Flora of New South Wales, vol. 1 to 4. Kensington, Australia.

Harvey N. (1977) The identification of subsurface solution disconformities on the Great Barrier Reef, Australia between 14°S and 17°S, using shallow seismic refraction techniques. *Proc. Third Intern. Coral Reef Symp.*, Miami, Florida: 45-51.

Heatwole H. (1976) The ecology and biogeography of coral cays, in: Jones O.A. & Endean R. (eds.) Biology and geology of coral reefs 3 (Biology 2): 369-387. New York, Academic Press.

Heatwole H. (1981) A coral island. The story of One Tree Island and its reef: 200 p. Sydney, Collins.

Heatwole H & T.A.Walker (1989) Dispersal of alien plants to coral cays. *Ecology* **70**: 787-790.

Hill D. (1974) An introduction to the Great Barrier Reef. Proc. 2nd Intern. Coral Reef Symposium **2**: 723-731.

Hnatiuk R.J. (1990) Census of australian vascular plants. Austr. Flora & Fauna Series n° 11: 650 p. Canberra, AGPS Press Publ.
Hopley D. (1978) Geomorphology of the reefs and reef islands, Great Barrier Reef north of Lizard Island. GBRMPA Meeting, Towwnsville: 219-252.
Hopley D. (1982) The geomorphology of the Great Barrier Reef: Quaternary development of coral reefs : 453 p. New York, Wiley.
Hussey B.M.J., Keighery G.J., Cousens R.D., Dodd J. & Lloyd S.G. (1997) Western weeds. A guide to the weeds of western Australia: 254 p. The Plant Protection Soc. of West. Australia.
Jackes B.R. (1987) Revision of the Australian Vitaceae, 2. Cayratia Juss. *Austrobaileya* **2(4)**: 365-379.
Lanyon J (1986) Seagrasses of the Great Barrier Reef. *GBR Marine Pk. Auth., Sp. Publ. Ser.* **3**: 54 pp.
Lee Long W.J., Coles R.G., Helmke S.A & Bennett R.E. (1989) Seagrasses habitats in coastal, mid shelf and reef waters from Lookout Point in North-eastern Queensland: 18 p. Rep. to the GBR Marine Pk Authority, Dept. Primary Industr., Queensland Gov.
Macnae W. (1966) Mangroves in eastern and southern Australia. *Austr. J. Bot.* **14**: 67-104.
McLean R.F. & Stoddart D.R. (1978) Reef island sediments of the northern Great Barrier Reef. *Phil. Trans. R. Soc. Lond. A.* **291**: 101-117.
McLean R.F., Stoddart D.R., Hopley D. & Polach H. (1978) Sea level change in the Holocene on the northern Great Barrier Reef. *Phil. Trans. R. Soc. Lond. A.* **291**:167-180.
Maxwell W.G.H. (1968) Atlas of the Great Barrier Reef: V + 258 pp. Amsterdam, Elsevier.
Meikle R.D. & Hewson H.J. (1984) Nyctaginaceae. in: Flora of Australia. **4:** 18. Canberra.
Meischner D. (1996) Sealevel oscillations and growth history of the Great Barrier Reef, in Reitner J., Neuweiler F. & Gunkel F. (eds.) Global and regional controls of biogenic sedimentation. I. Reef evolution, Research Reports. *Göttinger Arb. Geol. Paläont.*, **Sb 2**: 71-76.
Neil D.T. (2000) Characteristics and significance of a sub-tropical 'Low Wooded Island': Green Island, Moreton Bay, Australia. *J. Coastal Research* **16**: 287-294.
Percival M. & Womersley J.S. (1975) Floristics and ecology of the mangrove vegetation of Papua New Guinea. *Bot. Bull.* (Handbook flora of Papua New Guinea) **8**: 96 p.
Price I.R., Larkum A.W.D. & Bailey A. (1976) Check list of marine benthic plants collected in the Lizard Island area. *Aust. J. Plant Physiol.* **3**: 3-8.
Ridley H.N. (1930) The dispersal of plants throughout the world: XX + 744 p. Dehra Dun, India (1990 Reprint).
Scoffin T.P. & McLean R.F. (1978) Exposed limestones of the Northern Province of the Great Barrier Reef. *Phil. Trans. Roy. Soc. Lond. A.* **291**:119-138.
Smith G.C. (1994) Nymph Island, Great Barrier Reef, Queensland. *Seabirds Islands* **223**: 53-55.
Smith J.M.B. & Heatwole H. (1985) Notes on the changing flora of Heron Island and some other coral cays of the Capricornia Group. *Qld. Nat.* **25**: 126-131.
Specht R.L. (1972) The Vegetation of South Australia, ed. 2: 328 p. Adelaide, Govt. Print.
Steers J.A. (1937) The coral islands and associated features of the Great Barrier Reef. *Geogr. J.* **89**(1): 1-28, 119-139.
Steers J.A. (1938) Detailed notes on the islands surveyed and examined by the geographical expedition to the Great Barrier Reef in 1936. Reports of the Great Barrier Reef Committee, Vol. IV, Pt. III, n° 7: 51-104.
Stoddart D.R. (1980) Mangroves as successional stages, inner reefs of the northern Great Barrier Reef. *J. Biogeogr.* 7: 269-284.
Stoddart D.R. & Fosberg F.R. (1991) Phytogeography and vegetation of the reef islands of the Northern Great Barrier Reef. *Atoll Res. Bull.* **349**: 1-19.
Tomlinson P.B. (1986) The botany of mangroves: XII + 413 p. Cambridge, Cambridge Univ. Press.
Veron J.E.N. (1978) Evolution of the far northern barrier reefs. *Phil. Trans. R. Soc. Lond.* **B 284**: 123-127.
Walker T.A. (1991) Pisonia islands of the Great Barrier Reef. 1. The distribution, abundance and dispersal by seabirds of Pisonia grandis. *Atoll Res. Bull.* **350**: 23 p.
West D.C., Shugart H.H. & Botkin D.B. (1981) Plant succession and soil development in coastal sand dunes of subtropical eastern Australia. In: Forest succession. Concepts and application, Springer Verl., New York, 107-131.
Westhoff V. & Den Held A.J. (1969) Plantengemeenschappen in Nederland: 324 p. Zutphen, Thieme.
Wheeler J.R., Rye B.L., Koch B.L. & Wilson A.J.G. (1992) Flora of the Kimberley region XXII + 1327 p. W.Australia, Dept. of Conserv. and Land Managemt.
Wightman G.M. (1989) Mangroves of the northern territory. *North. Terr. Bot. Bull.* **7**: 130 p.
Wilson K.L. & Johnson L.A.S. (1989) Casuarinales. Flora of Australia **3**: 100-174. Canberra, Australian Government Publishing Service.

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Scripta Botanica Belgica 43

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NYMPH ISLAND
FLORA AND VEGETATION OF A LOW WOODED ISLAND

Nymph Island is an inner-shelf coral island of the northern section of the Great Barrier Reef off Cooktown. Its flora ranks among the richest of the coral islands in spite of its limited area. This book gives a checklist of the 143 vascular plants belonging to 63 families, as well as a detailed description and analysis of its vegetation. Among the recognized units are salty grassland communities, six mangal communities, scrubby vine herb fields, a pioneering upper beach herbfield, Casuarina woodland and Manilkara broadleaf forest. Sandy soils are comparatively young. They were mainly studied under forest communities assuming that on progressively older terraces maturation leads to hemi-organic layers. Mapping the vegetation units shows the extent to which earlier maps were inaccurate, unquestionably so with regard to plant communities and geomorphological features. A new hypothesis about island structure and progressive setting up is thus suggested.

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